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SKIN EFFECT AND ITS PRACTICAL TREATMENT.
BY CLEM COPELAND.

FLOODING METHODS OF IRRIGATION.
BY S. T. HARDING.

PROSPECTIVE MARKET FOR IRRIGATION PUMPING.
BY JOSEPH JACOBS.

THE ELECTRICAL DEALERS' PROBLEM.
BY MAX LOEWENTHAL.

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Alphabetical Index to Advertisers, Page 8 Where to Buy It in the West, Page 9

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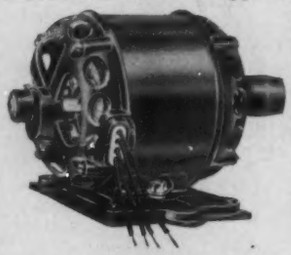

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SKIN EFFECT AND ITS PRACTICAL TREATMENT

BY CLEM A. COPELAND.

(The fact that an alternating current flows largely through the outer cross-section of a transmission wire, tending to forsake the central area, has long caused a troublesome problem in properly designing conductors and in predicting accurately the electrical phenomena that may result when the line is put into operation. In the following article and in a series of articles which will appear later, the author sets forth in its completeness the practical method of attack in order to properly handle this complicated problem. He explains the theory in an open, free manner devoid of higher mathematics, as he progresses in the discussion. The discussion draws upon the latest experimental data of the U. S. Bureau of Standards and other sources of information, calling attention to the fact that many formulas still appearing in current text books on the subject are incorrect. In this article the author shows by numerical illustration how the "skin effect" in any ordinary size of wire, rod or cable of solid cylindrical form composed of any non-magnetic metal at any frequency, up to say 3,000,000 cycles at any temperature may be readily and accurately found. The author is technical assistant engineer with the Los Angeles Aqueduct.—The Editor.)

Introductory.

When an alternating, oscillating or pulsating voltage is impressed upon a conductor of any form of cross-section, the resultant current forsakes the innermost filaments parallel with the direction of flow and crowds to the surface of the wire, cable or bar. This phenomenon is termed "skin effect," and is due to the fact that the deeper filaments have the greater self-induction and impedance to the flow of current.

The effects are more pronounced—

(a) The larger the superficial area of conductors for any given cross section.

(b) The greater the frequency of alternation, oscillation or pulsation of the current.

(c) The greater the magnetic permeability of the conductors; and

(d) The smaller the specific resistance of the material.

The reasons for the three former influences are quite self-evident, while the influence of the specific resistance is of a more obscure nature.

The results of the phenomenon of "skin effect" are:

(a) The ohmic resistance of any conductor is greater for a varying current than for a direct or continuous current of the same value.

(b) The inductance of a non-permeable conductive material, such as copper, aluminum, zinc or mercury, is smaller than it would be if the skin effect were absent; and

(c) The inductance of a permeable conductor, such as iron, steel, nickel and cobalt, is smaller than it would be if the skin effect were absent, but of course much greater than for the non-permeable substances.

The constantly increasing size of long distance transmission line conductors as the growth and combination of large systems occurs; the employment of bi-metallic wires and cables to obtain a high tensile strength; the use of iron and steel conductors in the place of, and on account of excessive cost of copper and aluminum and for special transmission uses; the increasing size of generators and transformers; and the employment of sustained high frequencies in wireless engineering, are among those factors which render the knowledge of skin effect of growing importance.

The phenomenon becomes prominent in non-magnetic wires or cables larger than .6 in. in diameter with 50 or 60 cycles and in smaller conductors at higher frequencies. Conductors used in connection with electric furnaces carrying upwards of 20,000 amperes must be subdivided "in order to use the conducting material to the best advantage and reduce its resistance to a minimum. The relative position of the conductors has also to be considered in order to prevent them from shielding one another. Mixing the phases reduces this effect and at the same time minimizes the reactance of the circuit, a matter of generally greater importance than the increase of resistance due to the unequal distribution of current in the conductors."

Skin effect is especially prominent in conductors of any ordinary size consisting of magnetic materials, from a No. 16 wire at 60 cycles to a steel rail used as the return in an alternating current railway system at 15 cycles, a 100 lb. rail, for instance, having 8.5 times more ohmic resistance at this frequency than for direct current.

The phenomena is of importance in rectangular busbars having the greatest dimension of cross-section

½ in. or more, in large low voltage transformer conductors, in continuous and alternating current generator conductors and in the conductors of standards of measurements and measuring instruments.

The present discussion will be limited to the consideration of the skin effect in connection with the flow of truly or approximately sinusoidal alternating currents.

The mathematical determination of the skin effect on the resistance and inductance in non-permeable cylindrical bars or tubes, when the return conductor is distant several times the diameter of the conductor or when the return conductor is concentric with the one being considered, is one of the most beautiful and exact demonstrations of mathematical physics. Perhaps no more charming and complicated illustration of the agreement between theory and practice exists. Unfortunately the complete understanding of the problem involves an advanced course in differential equations. The co-ordination of the results of theory and practice, only will be summarized herein for practical reference.

The mathematical determination of the skin effect in permeable conductors of any form is impossible. It is rarely possible in conductors of any material, whether non-magnetic or magnetic, if not cylindrical in form or when the conductors are close together. As will be presently shown there is recourse to experimental and empirical curves which enable the solution of most any ordinary problem in a more or less satisfactory manner.

Non-Magnetic Cylindrical Conductors—Solid Wires or Rods.

Referring to Fig. 1, suppose a sinusoidal alternating current to be flowing in a direction at right angles to the paper through the conductor whose cross-section is shown at A_1. The return conductor A_2 is assumed to be an infinitely great distance away and the conductor A_1 under consideration is assumed to be straight and of an infinite length.

The shading of the cross-section of Fig. 1, roughly represents the density of current, which is more accurately illustrated by the curve below, giving the exact maximum current density per circular mil at various points along the diameter as a function of the current density at the center, i.e., the current never reaches more than .00002 of an ampere in the circular mil forming the axis of the conductor, while in the layer of circular mils forming the "skin" of the conductor the current reaches a maximum at some instant of time of .003 of an ampere, or 150 times greater than at the center, while the whole conductor is carrying an average of .00058 of an ampere per circular mil.

The case just cited is that of a 22,564,400 circular mil cylindrical copper conductor 4.7502 in. in diameter at 68 deg. F. carrying a 60 cycle alternating current of 13,087 amperes.

The same distribution of current would obtain in a conductor of copper .47502 in. in diameter at a frequency of 6000 cycles per second.

In these instances it is seen that the inner part of the conductor, having a diameter of fully half of the total diameter, or one quarter of its area, could be dispensed with without seriously affecting the resistance to alternating currents.

The engineer is perhaps more concerned with the effects of this phenomena on the characteristics of the circuit which influence the power and voltage efficiency of the transmission.

Consider the characteristics of the circuit as illustrated in Fig. 1 as follows:

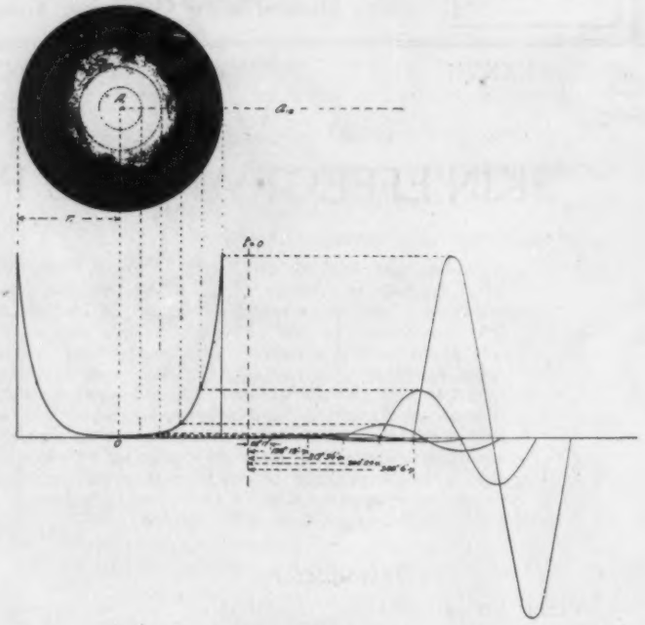


Fig. 1.

R_{dc} — the resistance of the conductor to direct current in ohms or the resistance to an alternating current of the same root-mean-square value, if there were no skin effect.

R_{ac} —the resistance of the conductor to alternating currents in ohms; resulting on account of skin effect.

K_R —The ratio R_{ac}/R_{dc} (Always greater than unity).

L_{1dc} —the coefficient of self-induction of the circuit in henries, due to the lines of force obtaining on the interior of the conductor which would result by virtue of a direct current, or if there were no unequal current distribution while an alternating current of the same root-mean-square value obtained. As a matter of fact this value is always .00001524 henries per thousand feet of conductor in the case of non-permeable conductors. In other words, unit direct current in the conductor would produce .00001524 of a line per thousand feet on the inside of the conductor itself, regardless of the size of the conductor.

L_{1ac} —the interior coefficient of the self-induction in henries due to the alternating current which results from skin effect.

K_L —the ratio L_{1ac}/L_{1dc}, always less than unity, theoretically, when non-magnetic conductors are used, possibly less than unity for nickel or cobalt, but always greater than unity for iron or steel.

L_e—the exterior coefficient of self-induction in henries, which is the same for either direct or alternating currents and independent of the material of the conductor, being in the above instance equal to $(.000140366 \text{ Log}_{10} 24000/r_1 - .0000609602)$ henries per 1000 ft. of conductor, being the number of lines exterior to the conductor produced by one ampere in the conductor; in which

r_1 = radius of conductor in inches;

f = frequency in cycles per second.

Organizing the above quantities, we have

Z_{ac} = Impedance in ohms by virtue of skin effect.

$$= \sqrt{[R^2_{ac} + 4\pi^2 f^2 (L_{1ac} + L_e)^2]}$$

$$= \sqrt{[K^2_R R^2_{dc} + 4\pi^2 f^2 (K_L L_{1dc} + L_e)^2]} \quad \ldots\ldots\ldots (1)$$

$$= \sqrt{[K^2_R R^2_{dc} + 4\pi^2 f^2 (K_L .00001524 + .000140366 \log_{10} 24000/r_1 - .0000609602)^2]}$$

For convenience this may be written in the following form:

$$Z_{ac} = \sqrt{(K_R R_{dc})^2 + 4\pi^2 f^2 \left[\frac{K_L 15.24}{10^6} + \left(\frac{140.366}{10^6} \log_{10} \frac{24000}{r_1} - \frac{60.902}{10^6}\right)\right]^2} \quad \ldots\ldots (2)$$

in ohms per 1000 ft. of conductor

Lord Rayleigh and others have developed exceedingly complicated formulae for the determination of K_R and K_L, which require mathematics beyond the scope of this paper for their satisfactory understanding. Recently, however, extended tables have been prepared rendering equation (2) easy of solution.

TABLE I.

$\varkappa$	K_R	K_L	$\varkappa$	K_R	K_L
0.0	1.00000	1.00000	6.6	2.60313	0.42389
.1	1.00000	1.00000	6.8	2.67312	0.41171
.2	1.00001	1.00000	7.0	2.74319	0.40021
.3	1.00004	0.99998	7.2	2.81334	0.38933
.4	1.00013	0.99993	7.4	2.88355	0.37902
0.5	1.00032	0.99984	7.6	2.95380	0.36923
.6	1.00067	0.99966	7.8	3.02411	0.35992
.7	1.00124	0.99937	8.0	3.09445	0.35107
.8	1.00212	0.99894	8.2	3.16480	0.34263
.9	1.00340	0.99830	8.4	3.23518	0.33460
1.0	1.00519	0.99741	8.6	3.30557	0.32692
1.1	1.00758	0.99621	8.8	3.37597	0.31958
1.2	1.01071	0.99465	9.0	3.44638	0.31257
1.3	1.01470	0.99266	9.2	3.51680	0.30585
1.4	1.01969	0.99017	9.4	3.58723	0.29941
1.5	1.02582	0.98711	9.6	3.65766	0.29324
1.6	1.03323	0.98342	9.8	3.72812	0.28731
1.7	1.04205	0.97904	10.0	3.79857	0.28162
1.8	1.05240	0.97390	10.5	3.97477	0.26832
1.9	1.06440	0.96795	11.0	4.15100	0.25622
2.0	1.07816	0.96113	11.5	4.32727	0.24516
2.1	1.09375	0.95343	12.0	4.50348	0.23501
2.2	1.11126	0.94482	12.5	4.67993	0.22567
2.3	1.13069	0.93527	13.0	4.85631	0.21703
2.4	1.15207	0.92482	13.5	5.03272	0.20903
2.5	1.17538	0.91347	14.0	5.20915	0.20160
2.6	1.20056	0.90126	14.5	5.38560	0.19468
2.7	1.22753	0.88825	15.0	5.56208	0.18822
2.8	1.25620	0.87451	16.0	5.91509	0.17649
2.9	1.28644	0.86012	17.0	6.26817	0.16614
3.0	1.31809	0.84517	18.0	6.62129	0.15694
3.1	1.35102	0.82975	19.0	6.97446	0.14879
3.2	1.38504	0.81397	20.0	7.32767	0.14128
3.3	1.41999	0.79794	21.0	7.68091	0.13456
3.4	1.45570	0.78175	22.0	8.03418	0.12846
3.5	1.49202	0.76550	23.0	8.38748	0.12288
3.6	1.52879	0.74929	24.0	8.74079	0.11777
3.7	1.56587	0.73320	25.0	9.09412	0.11307
3.8	1.60314	0.71729	26.0	9.44748	0.10872
3.9	1.64051	0.70165	28.0	10.15422	0.10096
4.0	1.67787	0.68632	30.0	10.86101	0.09424
4.1	1.71516	0.67135	32.0	11.56785	0.08835
4.2	1.75233	0.65677	34.0	12.27471	0.08316
4.3	1.78933	0.64262	36.0	12.98160	0.07854
4.4	1.82614	0.62890	38.0	13.68852	0.07441
4.5	1.86275	0.61563	40.0	14.39545	0.07069
4.6	1.89914	0.60281	42.0	15.10240	0.06733
4.7	1.93533	0.59044	44.0	15.80936	0.06427
4.8	1.97131	0.57852	46.0	16.51634	0.06148
4.9	2.00710	0.56703	48.0	17.22333	0.05892
5.0	2.04272	0.55597	50.0	17.93032	0.05656
5.2	2.11353	0.53506	60.0	21.46541	0.04713
5.4	2.18389	0.51566	70.0	25.00063	0.04040
5.6	2.25393	0.49764	80.0	28.53593	0.03535
5.8	2.32380	0.48086	90.0	32.07127	0.03142
6.0	2.39359	0.46521	100.0	35.60666	0.02828
6.2	2.46338	0.45056	oo	oo	0.
6.4	2.53321	0.43682			

These ratios depend upon the value of the argument

$$\varkappa = \sqrt{\frac{2(2\pi r_1)^2 f}{\rho}} = \frac{2\pi r_1}{.3937} \sqrt{\frac{2f}{10^9 \rho}}$$

$$= 22.570 r_1 \sqrt{\frac{f}{10^9 \rho}} \quad \ldots\ldots\ldots (3)$$

ρ = Specific resistance of the conductor in ohms per centimeter cube, that is the resistance of one centimeter length of a conductor one centimeter in cross-section, at the temperature existing in the conductor at the time.

The mathematical development of (3) theoretically involves the permeability μ, thus $\varkappa = 22.570 r_1 \sqrt{(\mu f/\rho)}$. Practically, however, this has no application as will be shortly shown.

Having r_1, ρ and f, determining the argument, $\varkappa$, the Table I has been calculated by the U. S. Bureau of Standards for finding K_R and K_L.

It is important to note from the argument $\varkappa$ and the above table, that K_R increases and K_L decreases directly with the superficial area of the conductor, the square root of the frequency and inversely as the square root of the specific resistance.

The following are average values of ρ which may be used in connection with (3) in the absence of measured values:

Table II.

Aluminum, hard drawn at 20 deg. C.	2,828.0
Carbon (Arc-Lamp)	4,000,000.0
Constantan	50,000.0
Copper, soft drawn, at 0 deg. C., 32 deg. F.	1,589.7
Copper, soft drawn, at 15 deg. C., 59 deg. F.	1,690.5
Copper, soft drawn, at 20 deg. C., 68 deg. F.	1,724.1
Copper, soft drawn, at 25 deg. C., 77 deg. F.	1,757.6
Copper, hard drawn, at 0 deg. C.	1,632.0
Copper, hard drawn, at 15 deg. C.	1,738.0
Copper, hard drawn, at 20 deg. C.	1,773.0
Copper, hard drawn, at 25 deg. C.	1,806.0
Copper sulphate, concentrated solution	21,739, 100,000.0
Gold	2,222.2
Graphite	from 250,000 to 1,250,000.0
Iron	from 9500 to 13,000.0
Lead, Ave. approximate, at 20 deg. C.	19,000.0
Manganin	41,667.0
Mercury	943,396.0
Neckelin	41,667.0
Platinum	10,000.0
Silver, Ave. approximate at 20 deg.	1,600.0
Steel	13,000 to 22,000.0
Tin, Ave. approximate at 20 deg. C.	10,000.0
Zinc, Ave. approximate at 20 deg. C.	6,000.0

As regards practical frequencies involved the following may be of service for reference:

Table III.

Commercial frequencies:	
On the Pacific Coast	50 and 60
In general, in U. S.	25, 40, 60, 133
In England, mostly	50 and 100, but many of 40, 60, 67, 68, 70, 75, 77, 80, 83, 83.5, 87, 87.5, 90, and 93
In Japan, "Of 774 generators, 30 operate at 25 cycles, 226 at 50 cycles, 467 at 60 cycles, 9 at 100 cycles, 19 at 125 cycles, and 23 others at various odd frequencies."	
Radio frequencies	350,000 to 3,000,000
Lightning phenomena	10,000 to 1,000,000
Telephone frequencies:	
Pitch of average man's voice	85 to 160
Pitch of average woman's voice	150 to 320
Maximum involved in ordinary speech	3,000
Highest frequency of speech, produced by whispering Z	5,000
Frequency in speaking u	1,100
Musical sounds: Lowest audible sound av. person	16 to 24
Highest Do	12,000 to 41,000
Lowest perfect musical note, E, of double bass	41 1/7
Highest orchestral note, d of piccolo flute	4,752

Illustrative of the use of this treatment take the extreme case shown in Fig I; thus:

Problem I.

$r_1 = 2.3751$.

$f = 60.0$ cycles.

$10^9 \rho = 1724.1$ absohms at 20° C.

$\varkappa = 22.570 \times 2.3751 \sqrt{(60/1724.1)} = 10.000$.

Reference to Table III shows:

$K_R = 3.79857$; $K_L = .28162$.

which may be substituted in equation (2), determining the true resistance, inductance and impedance of the circuit.

The accuracy of this method is almost imperceptibly impaired when the return conductor extends parallel to and only a short distance from the one under consideration, in which case the formula of the characteristics of the circuit is changed to the following:

$$Z_{ac} = \sqrt{\left(K_R R_{dc}\right)^2 + 4\pi^2 f^2 \left[\frac{K_L 15.24}{10^6} + \frac{140\ 36612}{10^6} \log_{10} \frac{A_{12}}{r_1}\right]^2} \quad \text{------ (4)}$$

in ohms per 1000 ft. of one wire only, the other wire having the same impedance, provided that it is the same kind and size of conductor.

Here A_{12} = interaxial distance between the conductors A_1 and A_2 in inches.

It should be observed that if the circuit is short, say 50 ft. in length, and the distance between conductors is great, say 60 inches, L_e is influenced by the presence of the end connections and a complicated formula for the exterior self induction, of a rectangle must be used as follows, and substituted in equation (1);

R_{dc} = the total d.c. resistance of the entire rectangle, in ohms.

L_{idc} = the total internal self-induction.

$$= \frac{15.24}{10^9} \cdot \frac{2}{12}\left(1 + A_{12}\right)$$

henries, where l = the interaxial length of the rectangle in inches.

$$L_e = \frac{30.48}{10^9} \cdot \frac{41}{12}\left[\log_{10} \frac{A_{12}}{r_{1,2}} + \frac{A_{12}}{l} \log_{10} \frac{2A_{12}}{r_{12}\left(1 + \frac{A_{12}}{l}\right)} - \frac{2A_{12}}{l} + \frac{2 r_{1,2}}{l}\right]$$

= the total external self induction for the entire rectangle.

For rectangles approaching a square a still more complicated formula must be used for great accuracy.

Recently Mr. A. E. Kennelly has verified the correctness of the above treatment for copper and aluminum conductors in a thorough fashion, as shown in the following series of tests on No. 0000 B. & S. copper wire, the return conductor being 24.082 inches in interaxial distance, A_{12}, from the other. The conductors consisted of specially selected soft copper rods of about 101.3% new A. I. E. E. standard of conductivity.

Table IV.

A_{12} in.	Cycles, f.	Temp. C°	Observed K_R	Observed K_L	Computed K'_R	Computed K'_L
24.082	60	23.5	1.0038	1.024	1.0046	.9977
	306	24.2	1.111	.9714	1.108	.9463
	888	25.0	1.578	.7456	1.571	.7311
	1600	25.6	2.042	.5742	2.036	.5599
	2040	26.2	2.279	.5126	2.261	.4959
	3065	27.1	2.694	.4099	2.701	.4071
	3950	27.4	3.034	.3618	3.028	.3595
	5000	27.9	3.361	.3195	3.371	.3202

Verifying the third line in the above table for illustration, we have:

Argument $\varkappa = 22.570 \times .23 \sqrt{888/1735.73} = 3.713$.

Interpolating in Table I between 3.7 and 3.8 there is obtained

$K_R = 1.571$ and $K_L = .7311$, which differ by 1% and 2% respectively from the experimental values.

The discrepancy is greater in the case of K_L since it was found by subtracting a calculated $K_L L_{idc}$ from the total observed self-induction of the circuit.

The discrepancy in the above case with K_R is greater than at any of the other frequencies, and the error is eliminated entirely when a curve is drawn connecting f, K_R and K_L as shown in Fig. 3. These results are remarkable when the intricacies of the problem are understood from a mathematcal, physical and practical standpoint.

No. 0000 aluminum wires were also tested and show a similar perfect agreement with the theoretical calculations.

The results in Table IV and those for the No. 0000 aluminum wire are shown in the curve of Fig. 3, being the two lower curves in the "nest."

It has been previously inferred that this discussion was not accurate when the conductors were near together. The reason for this lies in the fact that parallel currents traveling in opposite directions with the lines of force around such currents, opposite in directive force produce a mutual inductive disturbing effect, causing an eccentric distribution of current over the cross-section of the wire.

Referring to Fig. 1, in which the return conductor is at an infinite distance away, it is seen that the interior lines of force ϕ_i as well as the exterior lines ϕ_e form concentric circles about the axis of the conductor.

In Fig. 2 there is illustrated the condition induced by virtue of the two conductors being close together, wherein the current is crowded to the inner crescents of the conductors and the interior and exterior lines ϕ_i and ϕ_e are eccentric with the axis of the conductors.

This "proximity effect" on the "skin effect" is nicely illustrated by Table V and the curves in Fig. 3 as results of further tests by Kennelly, wherein it is seen that as the No. 0000 wires are brought closer together, K_R increases rapidly above the value given by the U. S. Bureau of Standards in Table I. In general this table can be used when $A_{12} > 2.5\ r_1$, up to the commercial distribution or transmission frequencies of 133 cycles and when $A_{12} > 125\ r_1$, up to say, 7500 cycles and perhaps far beyond, with No. 0000 B. & S. copper wire.

This nest of curves is valuable as forming a very reliable basis, for a preparation of other sets of curves for any special case, by interpolation and inductive

reasoning which could be made sufficiently dependable for ordinary use.

TABLE V.
Being an Extension of Table IV.
See curves of Fig. 3.

A_{12} Inches.	Cycles, f.	Temperature, C°	Observed, K_R
8.334	60	17.2	1.0058
	288	15.2	1.106
	868	15.2	1.584
	1663	15.0	2.120
	2061	14.9	2.313
	3063	15.2	2.755
	3112	15.4	2.781
	3860	15.3	3.067
	5040	15.4	3.446
2.9795	60	18.5	1.0087
	266	18.9	1.100
	582	19.3	1.354
	923	20.4	1.640
	1465	20.7	2.037
	2019	20.9	2.344
	1992	21.0	2.322
	3028	21.0	2.851
	3960	21.6	3.145
	5320	....	3.558
.7748	60	....	1.0124
	239	....	1.132
	671	....	1.604
	1068	16.3	1.981
	1509	16.5	2.330
	1991	16.9	2.643
	1988	17.2	2.638
	2486	17.8	2.912
	3028	18.0	3.179
	3880	18.3	3.587
	4900	18.4	3.995
.47165	60	21.1	1.0172
	236	21.4	1.244
	740	21.5	2.231
	1000	21.5	2.688
	1473	21.2	3.460
	2038	21.0	4.272
	3058	20.9	5.522
	3918	21.0	6.449
	5170	21.1	7.512

Such a process is illustrated in Problem III (appearing in a future issue), which could be extended for the insertion of other curves between the ones shown.

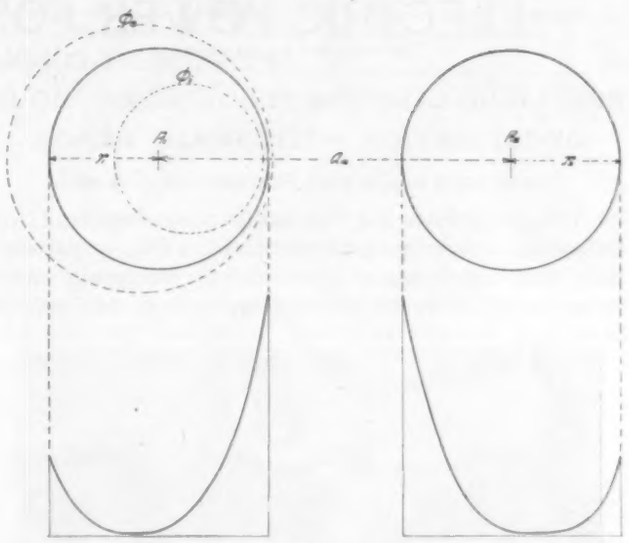


Fig. 2.

The "skin effect" in any ordinary size of wire, rod or cable of solid cylindrical form of any non-magnetic metal at any frequency, up to say 7500 cycles, at any temperature, is therefore very readily and accurately found, if we except cables between 1200 and 7500 cycles.

(To be continued.)

Philippine water-power sites are not being developed at present. Several concessions have been granted, but the concessionaires are apparently waiting more favorable conditions.

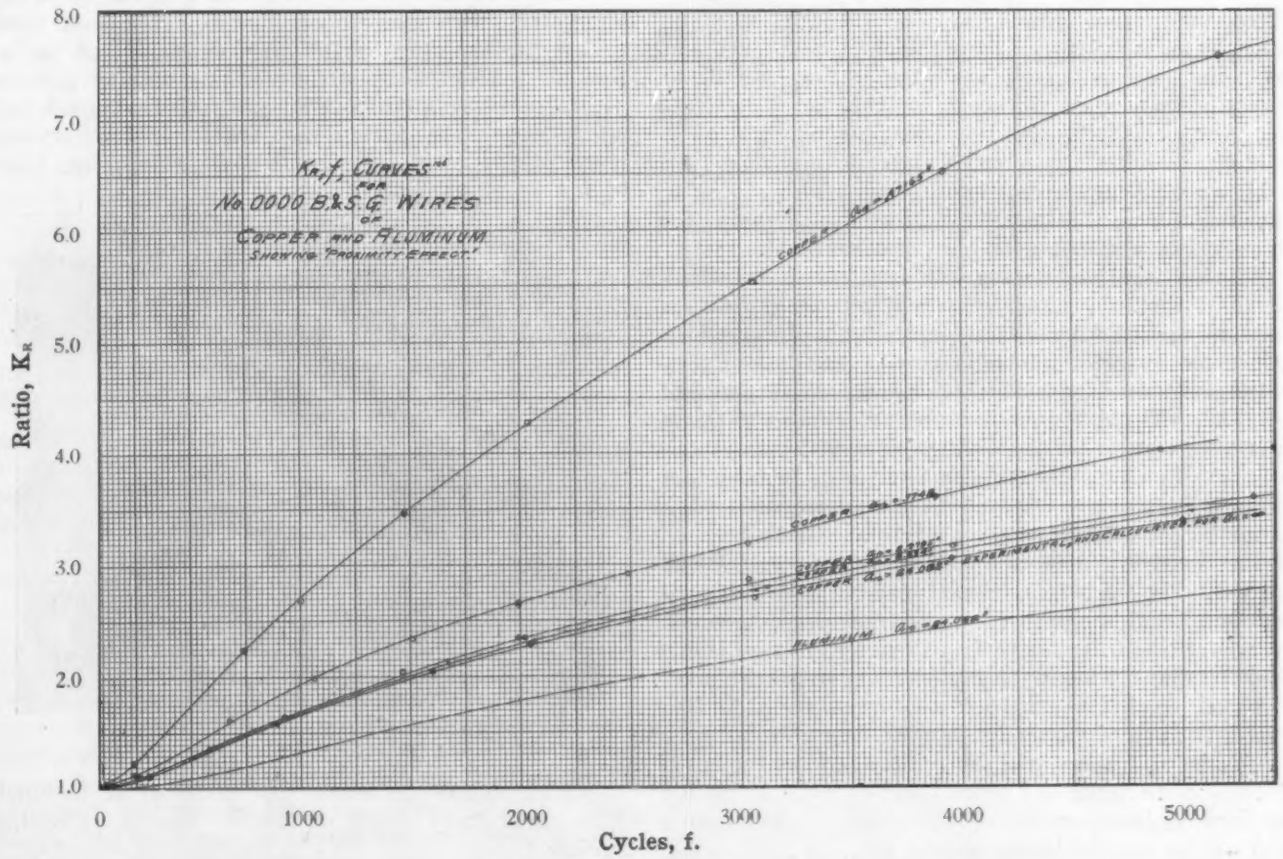


Fig. 3.

ELECTRIC POWER FOR IRRIGATION PUMPING

DEPARTMENT CONDUCTED BY S. T. HARDING

PREPARING LAND FOR FLOODING METHODS OF IRRIGATION WITH SMALL HEADS.

Importance of Careful Preparation of Land.

The importance of carefully preparing land for irrigation is now generally realized. This is particularly true where water is secured by pumping. Any water saved by more efficient methods of application

Flood Method of Irrigation.

results in a direct financial saving in the cost of pumping. Where water is secured from gravity systems on a flat rate per acre, such savings may not be as direct. Also, where power is secured on a flat rate per year, the saving with a given plant may not be as evident. With all sources of water supply, however, a higher efficiency in use results in a direct saving to the irrigator in the labor cost of application, and the more uniform distribution over the land.

The irrigating stream, or head, as it is called, secured from the usual individual pumping plant, is relatively small. A number 4 centrifugal pump, which is a quite common size for farms of 40 acres or less, will usually discharge a little less than one second foot or about 450 gallons per minute. A number 6 pump will discharge about 2 second feet or 900 gallons per minute. In California the usual irrigating heads under gravity canals vary from 5 to 20 second feet. For farms larger than 40 acres, larger pumps may be used if the wells are able to supply larger flows. Wells for individual farms, developed to yield over 2 second feet or 900 gallons per minute, are not usual, however. In some localities, the wells will not supply as much as 400 gallons per minute and smaller pumps are used. For such conditions where flooded crops are to be irrigated, the use of reservoirs is often desirable.

This discussion will be limited to methods of flooding with heads of 2 second feet or less. Irrigation by furrows involves different methods of distribution and will be separately discussed.

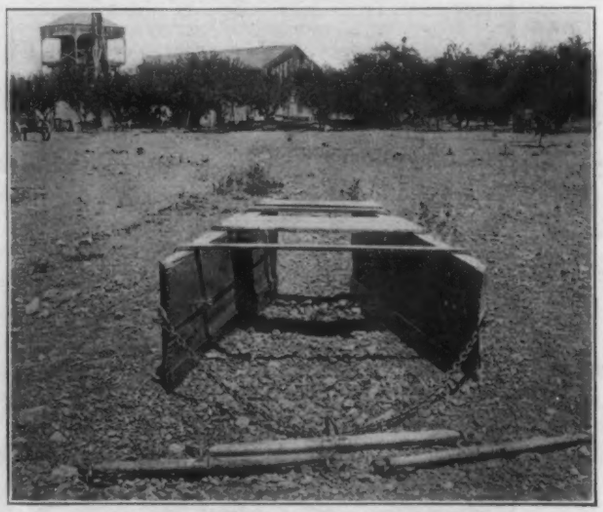
Irrigation by Flooding Defined.

By flooding irrigation is meant those methods by which the whole surface of the field is covered by the flowing water. With furrow irrigation, only a portion of the surface comes in direct contact with the irrigation stream. Various methods are used for flooding, those most usual under small pumping plant practice being the border, strip, or gravity check, the rectangular or square check, and in some cases the contour check. The free flooding from laterals, so usual in the irrigation practice in the mountain states, is but seldom used in the coast states when the supply is pumped.

In choosing the method to be used on any field, several factors must be taken into consideration. The most important of these are the character of the soil, the topography of the land and the crop to be grown. Other factors to be considered are the value of water and crop and the size of irrigating head available.

The character of the soil affects the preparation of the land in a number of ways. The moisture-holding capacity determines the frequency of irrigations. Where frequent irrigations are necessary, greater care in preparing the land is warranted, as the total saving per season is greater. For porous soils, smaller areas or lengths of run of the water over the surface are essential. The type of soil affects the slopes that can be used without washing.

The topography determines the direction of checks, and their sizes and slope. While for small checks it is possible to re-level the ground to give the slope desired, the limitations of cost make it necessary to adjust the arrangement to the topography as far as possible. This can best be done by making a topographic survey and map of the field. Where much levelling is required, such a map will often save several times its cost in the adjustments of checks to the land,



Smoother Used for Preparing Lands.

so as to reduce the amount of earth to be handled. It is particularly useful on land of uneven or rolling surface.

Alfalfa is the principal flooded crop grown under small pumping plants. Such crops as grain may be used for short periods, but most of the land prepared for flooding is planned for use in alfalfa. Cultivated crops are usually handled by furrow irrigation.

How the Irrigation Is Planned.

In planning the irrigation of a field, one of the important points to be considered is the size of the checks. This should be determined from an understanding of the conditions of flow of water over soils and its absorption. On porous soils it is difficult to secure uniform application. The area adjacent to the point where water is turned into a check absorbs water for a longer time than the part of the check furthest from the turnout. In order to secure reasonably uniform application, it is necessary to either reduce the size of checks or increase the rate of flow. On heavy soils it may be difficult to secure sufficient absorption, and the land should be prepared so that water can be run for relatively long periods in each check.

Various observations have been made on the rates at which soils absorb water. In applying water to dry soil, particularly where the surface has been previously loosened as by cultivation, a rapid initial absorption or filling of the surface will take place. Following this, absorption is more uniform, the rate depending on the moisture properties of the soil. Such rates of absorption can be observed in a number of ways. One method on which there are many published measurements is to observe the rate of seepage from canals and express it in terms of the depth per day over the wetted area of the canal. From such observations, it has been concluded that for impervious soils the rate of absorption averages about 6 in. in depth per 24 hours; for rather pervious soils, 12 in.; and for pervious soils, 18 in. For porous soils, such as sands and gravels, it may amount to 3 ft. or more per day. The rate of absorption on fields during irrigation should be somewhat higher than these rates for canals continually subject to percolation. For some of the heavy adobe soils, the rate of absorption may be as low as 2 in. per day; on very sandy soils it may be as high as 10 ft. per day. Observations in India gave results varying from 6 to 16 in. and averaging 8 in. per day for loam soils, and from 1 to 5 ft. with an average of 22 in. for sandy soils

Rate of Absorption Factor Determining Size of Checks.

The importance of the rate of absorption in controlling the uniformity of application can be seen when the area on which different sizes of irrigating heads will be completely absorbed at different rates is considered. In Table I the area required to completely absorb flows of ½, 1 and 2 second feet are given. From this table it is seen that if one-half second foot or the discharge of a number 3 pump is turned into a check, the soil which absorbs water at the rate of 18 in. per day, the whole would be absorbed on 0.7 acres. If such a check contained one acre, all the flow would be absorbed before the steam reached the further end of the check. The area of the check should be adjusted so that the proportion of the flow being absorbed will not be large, in order that the larger part of the head may be available for reaching the further portion of the checks.

Table I.—Areas in Acres on Which Different Sizes of Irrigating Heads Will Be Entirely Absorbed for Different Rates of Absorption.

Rate of Absorption, in. in Depth per 24 hr.	Size of Irrigating Head		
	One-half Sec. ft. or 225 gal. per Minute.	One Sec. ft. or 450 gal. per Minute.	Two Sec. ft. or 900 gal. per Minute.
6	2.0	4.0	8.0
12	1.0	2.0	4.0
18	.7	1.3	2.7
36	.3	.7	1.3

If it is considered that at least one-half of the total head should be available for advancing the flow across a check, and not over one-half be absorbed at any time by the area covered, the maximum size of checks for the different conditions would be one-half the areas given in Table I. This emphasizes the need of small

Fields Being Flooded for Irrigation.

checks or of large heads in handling porous or sandy soils. For medium or heavy soils other conditions usually limit the size of checks to not over one acre per second foot of supply.

Care in preparing land for small heads is relatively more important than for large heads. As the depth of flow over the check is usually small, smaller variations in levelling will increase the difficulty of covering the whole area. Small checks require the moving of less earth on a given field than large ones, as they can be more closely fitted to the topography. The length of levees or dikes and usually of field ditches is greater, however.

Checking of Land Should Be Well Done.

Checking land, to be well done, requires a considerable amount of careful finishing. Such finishing materially affects the uniformity and ease of irrigation. The quality of the finished work cannot be defined in specifications or determined by ordinary inspection. For this reason, such work is not well suited to being handled by contract, but can best be done by the owner of the land himself. On rough land, involving the moving of considerable amounts of earth in pulling off high spots and filling holes, the general grading can often be handled by contract, but even where outside teams are employed it is usually preferable to hire them on a day basis, rather than at an acreage rate.

The Fresno is the implement most commonly used in levelling land. For larger tracts, some of the different forms of power graders give economical results. For usual pumping conditions, the areas are too small to warrant the purchase of such equipment, although if available it may sometimes be hired to advantage for the general grading. For the smaller checks, particularly the narrow strip checks, an ordinary road grader can be used to advantage.

LETTERS TO THE EDITOR.

The Electrical Dealers' Problems.

Sir:—Contrary to custom, I shall begin this discussion with a P. S., namely, a Preparedness Sentence, by stating that this intended letter has assumed the proportions of an article, for the length of which I make apologies and for the publication of which you may earn no one's gratitude but my own. I cannot, however, any more than a fish can refrain from entering the water, desist from participating in the discussion of the "Electrical Dealers' Problems," so ably expounded in the paper by M. L. Scobey, published in your columns last week.

I wish to state at the outset, for obvious reasons, that, regardless of my present business connection, I hold no brief for, nor do I represent in the presentation of these views, any firm or interests, but that my sympathies (please note the plural, singular as it may seem after reading what is to follow) are now and always have been with the electrical interests, particularly the electrical dealer. This must be evident to anyone who is acquaintd with my activities in the electrical field, covering a period of 27 years, as manufacturer, jobber, dealer, electric business organizer, central station sales manager, editor and teacher, certainly a multiphase experience, enabling me to view the situation from every angle. I believe, furthermore, that business relationships, like personal friendships, lose much of their fervor and value when they resolve themselves into "mutual admiration societies" and that occasional jolts and criticisms resulting from a sort of inventory of one's views and interests by someone who is honestly concerned about them, are as wholesome as they are desirable.

And surely, if this be true, it applies most forcibly to a discussion of the retail end of the electrical industry, which in Mr. Scobey's own words, has been, up to two years ago, "The tail-end of the industry, whereas it should be the foremost." He regrets the fact that: "The stores outside of the electrical industry are disposing of from three to four times as many electrical devices as the electrical shops," and he makes the laudable plea to "reclaim the business and get it flowing in the proper, natural channels—namely, to the retail electrical dealer." He admits that the electrical stores have been "sadly neglected," that "80 per cent of the buying is done by women," that "it is to the advantage of the public to buy electric devices at an exclusive electrical shop," and that while he states that "we should show our appreciation of the jobbers by supporting them," he admits that "it is quite evident that the manufacturer is beginning to realize that there is such a person as the electrical dealer." These and other statements are food for further thought and discussion, based on the writer's personal experience and observation.

I admire Mr. Scobey's introspection, which has led him to recognize the dealer's shortcomings and difficulties and his laudable purpose of having him come into his own by earning for himself the respect, confidence and support of the buying public. But I venture to attack the problem from a different and perhaps broader angle than may be included in the improvement of sales methods and the motives which are actuating the jobbers and central stations in giving their support to the electrical dealer, while not for a moment denying similar treatment to the department, hardware and drug stores, which are generally accused of price cutting and robbing the electrical dealer of his legitimate means of livelihood.

We must not, in our discussion, also lose sight of the fact that the manufacturer in trying to find an outlet for his product, has the hardware and household goods jobber to deal with in addition to the electrical jobber and that the former will support and supply a class of dealers which the latter would and could not reach through his salesmen. So at the outset we must absolve the electrical jobber from any responsibility if "approved" electrical merchandise reaches a non-electrical, undesirable dealer, nor can we blame the factory desiring to find a wider market for its product than can be found by the electrical jobber through his natural ally, the electrical dealer. I mention this merely to show the complexity of the situation which becomes further involved through the entrance into the field of the so-called non-association jobber, the "out-of-town" purchasing syndicates, the factories selling direct to "almost" jobbers or large dealers and also the many electrical jobbers admitting that the "non-electrical" business is extensive and desirable. And that we may not think for a moment that such an outlet is diminishing or unworthy of recognition let me quote from a recent article in the Housefurnishing Review on "Electrical Merchandising":

> "There is no other class of stores that furnish as logical an outlet for this class of appliances as the house furnishing store. The housekeeper is in the habit of coming to the house furnishing store for all her household purchases, which makes it easy for it to get all the business in this line if the proprietor cares to do so.
>
> "The time to get control of this class of business is the present. Electrical dealers as a class at present are not merchants in the true sense. While they are anxious to sell these household appliances, they have not yet learned how to go after the business, how to arrange proper displays in their stores and windows, in a word, they have not yet learned how to sell. They are studying methods, however, and learning fast. If a house furnisher, who is already a merchant, wants this business, he must go after it now and establish himself in the field before his brother in the electrical line has time to get his bearings.
>
> "During 1915 about ten million dollars' worth of electrical appliances were sold to the homes in the United States, an increase of about three million dollars over the previous year. This is an indication that the business is actually growing and is worth while handling. The profits are large and the tendency for the past two years is toward a maintenance of prices.
>
> "Everything tends to show that the sale of electrical household appliances is good business, a growing business, and a business that the house furnishing stores throughout the country ought to handle."

It would be folly, therefore, to imagine that we can ostrich-like stick the "outside" store's head into the ground and think that he will not be seen.

It is equally unreasonable to believe that we can crowd electrical goods out of these stores as it would be for exclusive camera, hardware or picture stores to eliminate the sale of this class of merchandise from department or household goods stores, where people

trustfully trade and where the time payment plan and credit extension are additional allurements.

Furthermore, the non-electrical merchant, besides being equipped with merchandising experience, has learned the value of electrically trained salespeople and one concern, operating a chain of stores throughout California, is even employing a specialist to give advice in regard to the class of merchandise to be purchased and train all its salespeople in the selling of electrical merchandise.

These stores frequently make the electric shop appear in the role of the "blacksmith shop" referred to by Mr. Scobey, with its small stock, limited variety, poorly lighted and shabbily dressed windows, and poor attention and it is folly to think that the non-electrical stores do not make repairs or that they offer none but inferior merchandise. I venture to say that one can buy such goods in as many electrical stores as non-electrical ones in proportion to their number.

The non-electrical store, called N. E. store hereafter, knows the value of bargain sales, however, and will frequently purchase, in view of its large purchasing power, a large quantity of "non-association" but approved appliances, direct from the factory and offer the article at an attractive price. This is not price-cutting, but good business. In Los Angeles, at this very time, six electrical retail stores are selling as many types of irons at $1.95 each and the ball in this direction was not started by a N. E. house. And, still worse, the various associations are not strong or active enough to stop this practice.

In San Francisco several "standard" articles are sold below "schedule" prices, one being sold at six different prices, at as many different places, which will allow the dealer 33 1-3 per cent profit, figured on the selling price, which many dealers believe to be a living profit.

And we furthermore know that the N. E. store, for reasons stated above, and others, is in a position to carry a larger variety of merchandise, which is a distinct selling advantage. A woman will ask for a H. P. or a U. or a W. or an A. iron and the store which carries all four types is more apt to make the average sale than the electrical storekeeper carrying but one or perhaps two types, largely because he deals with one jobber who represents but one factory and who, by giving the financially weak dealer credit, in the majority of cases, controls the policy and destiny of the store. So we have in most cities a W. or G. E. or H. P. or A. store, which is a distinct detriment to the dealer, but, under existing conditions cannot be altered. It is, however, a disadvantage under which the N. E. store does not have to labor, for he buys from any electrical or N. E. jobber or the factory direct.

Let us, for a moment, review a bit of history in this connection, so as to trace the entrance of the N. E. dealer into our "sacred" domain. I recall, how, as a manufacturer, sixteen years ago, I was forced to install an electrical department in Macy's department, store, New York, in order to find an outlet for my electrically-heated appliances, there being no strictly electrical stores in New York at that time. This worked so well that other manufacturers sold this firm direct much to their benefit and the disgust of the electrical fraternity. A little later a department of a similar nature was almost forced on the Wanamaker stores, and today more current-consuming devices are sold at this store, I understand, than in any electrical or N. E. store in New York City. And these and other large department stores are not price-cutters nor electrical blacksmith shops, but legitimate outlets for household appliances, electrically operated. If you want to find price-cutters look for them among the little electrical stores, struggling for existence, the store which cannot, from the protecting jobber, obtain a price, enabling him to live, just because he cannot buy in large enough quantities to entitle him to a fair margin of profit. Is it a wonder then, that so many electrical dealers succumb or are afraid to even make a real start? Let's try to find a remedy for this situation, it's equally important as window trimming and lighting. He says to the jobber: "Give me a better price and I'll sell more and therefore buy more," and the jobber replies: "You buy more and I'll give you a better price and then you'll sell more," a situation resembling the dog trying to catch his tail. I recall a similar condition years ago regarding the selling price of irons. We manufacturers had to set a price of $7.75 on them because dealers wouldn't buy them in quantities. They couldn't sell more because the central stations wouldn't reduce the price for current. So the public simply balked. Someone had to give way and in the course of events, price per kw. and list prices of irons were reduced, more were sold and more were made and everyone was happy. But someone had to start making a concession and this applies also to the above situation.

As you remarked editorially some time ago: "Some electrical jobbers have been so short-sighted as not to recognize that their own success depends upon the success of their cutomers," and it is no wonder, everything considered, that you were forced to the conclusion that, "Electrical contracting has a poorer financial rating than almost any other line of business." which, of course, means the dealer, for seven-eighths of the electrical stores are operated by persons in the contracting business.

And, furthermore, you wisely state, in commenting on the danger of overstocking, that, "The jobber is perhaps more at fault here than the dealer for the jobber at least knows the limitation of demand, whereas the dealer only sees the quantity discount." Personally I can see no reason why an electrical dealer should not also be a contractor, especially as it may give him a lease on life, any more than we criticise a millinery store for making hats, kodak stores for printing pictures and furniture houses for installing carpets. On the other hand, I find it most logical for people to go to drug stores for vibrators, to furniture houses for vacuum cleaners, sewing machine stores for motors, sporting goods stores for flashlights, house furnishing stores for ranges, percolators and irons, all electrically-operated. The fact is, that the electrical dealer, who is just learning the merchandising game, is deluding himself into thinking that while he was asleep, the N. E. man was also a Rip Van Winkle, while, as a matter of fact, the old-time merchant was

slowly but surely acquiring his electrical education and experience.

A few more facts, now, in regard to price cutting. While discussing the merits of the Stevens Bill, Michael Friedsam, president of B. Altman & Co., New York, made the following significant suggestion: "Let the dealer cut the price of goods he wishes to discontinue carrying, provided the manufacturer or his jobber does not accept the offer to buy back at the price at which the merchandise was sold—an offer which the retailer shall be required to tender him. This would be an equitable, fair and reasonable provision." I wonder what our electrical jobber would say about the possible enactment of such a provision, suggested by a very successful merchant. And what are the "legitimate" jobbers doing or what can they do to stop price cutting, except to refuse to sell to such "unscrupulous" stores, in which case the goods may be obtained through other channels or inferior goods be placed on the market. Perhaps a remedy will be suggested. As a matter of fact I have personally sent out dozens of letters from a N. E. house to manufacturers calling their attention to price cutting, while the electrical dealers stewed and fretted and complained to the jobbers and discovered a new and warmer abode for the culprit. I have before me, also, a letter from an electrical dealer in San Francisco, which has a true ring to it, reading as follows:

"Enclosed is a list of changes I propose making on my retail prices due to increase cost of materials. I hope this information may be of value to you."

This letter was sent to six electrical and three non-electrical houses. But I have also, in contrast to this, a letter to a dealer from a purchaser, a state institution, which reads thus:

"In reply to your letter of ——, will say that on competitive bids we find your range to be too high to consider and will have to give the business to the ———— (here was inserted the name of a legitimate jobber of S. F.) etc."

What has the jobber to say to this, and is such a procedure conducive to bettering the condition of the dealer or deserving of the eulogy Mr. Scobey bestows upon him?

With regard to ranges I wish to quote the following from Mr. Scobey's paper: "Here is an opportunity to get in on the ground floor and keep this business for ourselves, but prompt and vigorous action must be taken, before the house-furnishing and department stores get started with the line. He continues: "We can get the start on our friends, the enemy," and: "The central stations are virtually handing this business to us on a silver platter."

There need be no fear on the part of the electrical dealer that his "enemy" will accept this lemon even if it were offered, under present conditions, on a gold platter, studded with diamonds, for the wise merchant is too wide-awake to fool away his time or waste selling ammunition in an attempt to market an article which does not give him a living profit. Let the electrical "merchant" do a little figuring for himself, before he attempts to compete against central stations and jobbers in this field, the exploiting of which logically belongs to the former. And the more ranges the central stations sell, for at least a year, the more business it will bring to the contracting end of the dealer's business.

Many more concrete cases could be cited to bring home to the electrical dealer the all important facts that: The non-electrical store will continue to merchandise electrical appliances.

To avoid price-cutting and the flooding of the market with undesirable material it would be good policy to invite such merchants into an "Electrical Appliance Dealers' Association," an independent organization whose chief object it might be to preach the fallacy of price-cutting and the advantages of maintaining a standard of quality. To thus practice cooperation, instead of preaching elimination and discrimination. To institute an open forum for the frank and fearless discussion of your problems.

And I want you all to know that the electrical dealers and the jobbers and central stations as well, have no better friend and well-wisher than the undersigned, that the above discussion is impersonal and unprejudiced, that I bear no ill will toward any one and should welcome a further discussion of "our" prob lems in your own midst, for I believe, with Jas. H. McGraw, that: "The biggest commercial problem in the electrical industry remaining unsolved is that of merchandising."

Let us co-operate, friends, in its solution, for in the words of the immortal genius, Benjamin Franklin, uttered during the discussion of the Declaration of Independence: "Gentlemen, if we don't hang together, we may all hang separately."

Very truly yours,

MAX LOEWENTHAL.

San Francisco, Cal., July 24, 1916.

AN ELECTRICALLY EQUIPPED HOME IN THE SAN JOAQUIN VALLEY.

The Hammond "Delta Home" situated in the outskirts of the town of Byron in the San Joaquin Valley, on what is to be the continuation of the Mount Diablo boulevard, consists of nearly two acres. The house is a typical illustration of the modern transformations that electricity can accomplish.

Everything throughout the house is electric. There are heaters in every room and instantaneous water heaters in the bathrooms. The Bayonet heater attached to the boiler has one unit of 8000 kilowatts and another of 1100. Every wire in the house is in a conduit.

Cooking with electricity is a distinct success. The range runs about $4.50 a month for a family of four. The kitchen is cool in summer and the preparation of a meal is a pleasure. In winter a heater in the kitchen keeps things nice and warm.

An automatic electric pumping plant is a feature of the yard. The cost of operation is nominal. The pumping plant also furnishes irrigation for the 9000 square feet of blue grass lawns and for the berries and vegetables.

As an instance of how cooking by electricity is receiving encouragement from all sides, actual count shows that about 175 electric ranges are now in use in the San Joaquin Valley at Tracy, Modesto, Oakdale, Manteca, and Byron. It is expected this number will be increased to 400 before the season is over.

PROSPECTIVE POWER MARKET FOR IRRIGATION PUMPING IN OREGON AND WASHINGTON.

BY JOSEPH JACOBS.

(Continued.)

The fact is that although the present ground water plane over a considerable portion of Central Oregon is near the surface there is no reason to expect an abundant supply from that source for irrigation purposes. Central Oregon is a high, broad plateau region with a meagre supply of rainfall and with no immediately adjacent high mountain ranges, enjoying heavy rainfall, the drainage from which can readily reach the general body of ground waters underlying the distant interior plateau. The Cascade Mountains, for instance, pours all the heavy runoff from its easterly slope into the Deschutes River whence it is then carried on to the Columbia with practically no effect whatever on Central Oregon ground water conditions. The present shallow depths to, and apparent abundance of, central Oregon ground waters result from the fact that these waters now represent an accumulation of years which has practically never been tapped by man. If general pumpage irrigation were instituted over the entire tillable area where shallow depths to ground water now prevail, the supply would soon be exhausted. Pumpage irrigation from wells is limited by the amount of ground waters that can annually reach a rather restricted local area within which the well is located, and Central Oregon does not present favorable conditions for large supplies of that character.

The conditions in Central Oregon are not at all comparable with those which obtain in the Sacramento and San Joaquin Valleys in California for these latter valleys are comparatively narrow; they constitute the lowest great drainage basins in the state and are flanked by mountain ranges of good water yielding capacity, none of whose drainage is intercepted and diverted away from these valleys but all of which, in numberless streams, is carried across and through them. Our Willamette Valley presents conditions more nearly comparable to those of California, and in this valley we may anticipate abundant supplies of ground water ready at hand whenever it becomes desirable to develop them by pumpage.

It may be said finally that the irrigation pumpage possibilities in Central Oregon are not as extensive as many suppose, particularly as measured by power requirements, and what is more pertinent to this particular inquiry, to the extent that they do exist they can be more economically served as part of, or incidental to, local gravity project developments, or by power which could be developed on the Deschutes River, which is a much nearer source of supply, and possibly by power which can be developed on the Chewaucan River which is a still nearer source of supply. It appears from investigations already made that power can be developed about as cheaply on the Deschutes as on the Columbia River, and besides being much nearer the central Oregon district it would have the further advantage of being more easily financed because of the lesser initial investment required. It is also likely, however, that the annual operating cost for a Deschutes power plant would be somewhat greater per unit of power output than would that of the Celilo plant because of the lesser magnitude of the former.

Willamette Valley.—This district was not assigned for specific consideration in connection with this investigation because of its very uncertain status in respect to irrigation and more particularly pumpage irrigation. Certainly the Willamette Valley is quite outside those portions of Oregon ordinarily classed as arid or semi-arid and its need for irrigation is therefore not immediately apparent. Despite its 36 in. of annual rainfall, however, it has an average rainfall of less than 3 in. during that season of the year which, by reason of its warmth and abundant sunshine, is best adapted to active plant growth, to wit: the months of June, July and August. So small an amount of summer rainfall is less than that of some of our so-called arid districts where irrigation is recognized as a prime necessity, and it at once suggests that here too irrigation might be practiced with profit as is being done, for instance, in the valley of the Po in northern Italy where both the annual and the summer rainfall is greater than that of the Willamette Valley.

The amount of irrigation water required would be from 12 in. to 18 in. per season, and there only remains to be proven that the increased crop returns would justify the cost of the irrigation development. While the writer is confident that this class of irrigation development can be justified and will ultimately be consummated in many districts, he recognizes that the case has not yet been fully proven for the Willamette Valley. He also recognizes that full and frequent proof must precede its general acceptance by the public and that any important development of irrigation along that line must await such acceptance and approval by the public, all of which will require time and education.

So far, too, as the proposed Celilo power project would be concerned in this irrigation development it must be proven that the irrigation water will be supplied by pumpage. Undoubtedly abundant ground water supplies for pumpage can be found in the Willamette Valley, as was pointed out in a previous section, but undoubtedly, too, large gravity supplies are available and at low cost, and practically all of these must be exhausted before any general demand or justification for irrigation by pumpage will arise.

A far more likely demand for Celilo power with respect to agriculture in the Willamette Valley will be in connection with drainage and the reclamation of wet lands. No data are now available to me for determining the area that might thus be reclaimed nor the amount of power required but the very low lifts usually involved in that class of development would indicate that the aggregate power demand would not be great. It might not, on its own account, be sufficient to justify long distance electric transmission but with the general commercial power that will be in demand throughout the Willamette Valley such transmission would be justified and cheap power would thus become available for irrigation purposes.

Other Areas Excluded.—Other areas of good agricultural land which came under my observation but which were finally not regarded as tributary to Celilo power on account of cost were as follows: Moses Lake District which now has some 900 h.p. in gasoline engine pumping plants and which may ultimately require 2000 h.p. to reclaim from 12,000 to 20,000 acres of land, Moses Lake, at lifts varying from 40 ft. to 150 ft.

Quincy Valley is an extensive plateau area of nearly a half million acres, which will ultimately be reclaimed by gravity but which, pending that development, is now practicing and will continue to practice some irrigation by pumpage from wells. Lifts will vary from 50 ft. to 300 ft., and it is believed that this demand, by reason of water limitations, will never exceed 3000 h.p.

Crescent Bar District on the Columbia River just south of Trinidad on the Great Northern Railway, may ultimately require about 200 h.p. to reclaim 1000 acres, about one-half of which is now under cultivation and served by a steam plant.

Cohassett District on the west shore of the Columbia River between Cohassett Station on the C. M. & St. P. Railway and Whiskey Dick Canon, may ultimately require 500 h.p. to reclaim 3000 acres at lifts ranging from 50 to 100 ft.

Richmond District on the west shore of the Columbia River immediately south of the main line and paralleling the Hanford branch line of the C. M. & S. P. Railway, may ultimately require 500 h.p. to reclaim 3000 acres, several hundred acres of which are already under cultivation.

It has been estimated that for all of the above districts with the possible exception of the Richmond District, the cost of Celilo power would be in excess of one-half cent per kilowatt hour and that some other form of power or electric power derived from some nearer source would prove more economical.

Existing Pumping Projects.—Along the entire course of the Columbia River from the proposed generating station at Celilo Falls to the northerly limit of proposed transmission at Beverly, private pumping plants are being operated, these ranging from the small gasoline plant of the individual farmer serving from 10 to 100 acres to the larger electric power pumping plants owned by corporations and serving several thousand acres. Among these latter are the plants of the Beverly Land Company, Hanford Irrigation Company, Pasco Reclamation Company, Burbank Company, Altalia Land Company, and the Northern Pacific Irrigation Company.

All of these companies will continue to require power, with the possible exception of the Northern Pacific Irrigation Company, which may ultimately be served by gravity supply from the proposed Yakima Valley Irrigation Project. The present cost of power to all of these companies is far in excess of that at which Celilo power could be delivered to them and all of them, except the Northern Pacific Irrigation Company, have therefore been included as possible users of Celilo power.

It is an interesting fact in connection with practically all of these larger corporate enterprises that the annual charge to the water user for maintenance and operation is appreciably less than the actual cost of pumpage and not infrequently is less than the cost of power alone. The water user and the public generally are not aware of this fact and are too prone to believe that the irrigation companies are reaping large profits from the annual maintenance and operation charge, whereas the very reverse is the case. The companies, of course, have generally provided for this operating loss in fixing the price of their land, thus creating a situation that is misleading, and the water users will, therefore, not come to a full appreciation of actual operating cost until they are themselves required to operate the pumping plants.

Resume and Conclusions.—By reference to Fig. 40 it will be noted that for all the irrigation pumping projects listed as possible future consumers of Columbia River power there are embraced some 635,000 acres of irrigable land of which amount 25 per cent is in the state of Oregon and about 75 per cent in the state of Washington. It will be noted too, that the motor capacity required for this aggregate development is 396,000 h.p. and that the installation required at the generating station will approximate 255,000 kw.

The average price at which it is estimated Columbia River irrigation power can be delivered to the motors at the pumping stations is about $10 per h.p. of connected load per irrigation season or about 0.35 cents per kw.-hr. of actual power consumption, this being about one-third the present average rates for such power. Such reduction in power rates must inevitably give impetus to the industry of irrigated agriculture by pumping and the extent to which the above estimates of gross acreage and gross power demand must be varied will depend largely upon whether or not the power rates herein assumed are actually achieved.

In this connection it should be stated that the above power rates are based upon the assumption of the transmission of large blocks of power and if the irrigation development is so slow or so restricted as not to require fairly large amounts of power then would the power rates need be increased. If on the other hand the power rates are decreased, whether from a policy of agricultural subsidy or because of an actual lesser cost of producing same, then could higher lifts be achieved than herein contemplated and a greater area of land be thus reclaimed. It should also be stated that commercial load demands may compel the construction of transmission lines that would render feasible some of those smaller irrigation projects which have been excluded because their limited size did not justify electric transmission on their account alone, and this would tend slightly to increase both area and power requirements.

Viewed from any angle it would appear that the irrigation pumping possibilities along the Columbia River valley, upon a basis of cheap power, are of sufficient magnitude to tax any auxiliary capacity that might economically be provided by the proposed Columbia River power development. In other words, there may be created such a demand for primary power, i.e., all year power required for manufacturing and general industrial purposes as to leave no considerable physical space available for auxiliary power house construction at the proposed power site. If the Priest Rapids and Benton Projects were excluded as not tributary to Celilo power and if the Castle Rock Slope area was appreciably sealed down or even entirely eliminated as being less economical than a gravity development, there would still remain a demand for the installation of at least 80,000 kw. of auxiliary power for irrigation purposes at the Celilo generating station, which in itself is larger than any single installation now on the Pacific Coast.

(To be concluded next issue.)

HOW— GENERAL FACTS, FIGURES AND THEORY OF CURRENT INTEREST

HOW TO COMPUTE THE HORSEPOWER RATING OF YOUR AUTOMOBILE.

BY ROBERT SIBLEY.

It is found by reference to collected data that for the safe operation of an automobile the piston speeed should never exceed 1000 ft. per minute.

On this assumption the Association of Licensed Automobile Manufacturers have agreed upon a rating of the indicated horsepower developed in the engines of an automobile simply by taking account of the number of engine cylinders and the diameter of each cylinder.

The indicated horsepower of any heat engine, whether it be steam engine, gas engine, Diesel oil engine, air compressor or automobile engine may be computed from the well-known formula:

$$H.P. = \frac{PLAN}{33000} \quad \ldots\ldots(1)$$

In which P = mean effective pressure.
L = length of stroke in ft.
A = area of cylinder bore in sq. in.
N = number of working strokes per min.
If S = the piston travel per min. in ft.

Then $N \times 4 \times L = S$, or $NL = \frac{S}{4}$

And $A = \frac{\pi d^2}{4}$ in which d is piston diam. in inches.

$\therefore$ in the formula $H.P. = \frac{PLAN}{33,000}$, we have by substituting for N L and for A,

$$H.P. = \frac{PLAN}{33,000} = \frac{P \times \frac{S}{4} \times \frac{\pi}{4} d^2}{33,000} = \frac{\pi}{16 \times 33,000} P d^2 S$$

Experimental data:

A long series of experiments have established the fact that the mean effective pressure P developed in an automobile engine cylinder under full load conditions is such that the factor $\frac{\pi}{16 \times 33,000} P$ in the above expression may be replaced by a factor $\frac{C}{24,200,000}$ in which for the best engines C has a value of 12,950, for the normal engine 9786, and for the worst type of engine 7960.

Hence we have for the indicated horsepower of an automobile engine that

$$H.P. = \frac{\pi}{16 \times 33,000} P d^2 S = \frac{C d^2 S}{24,200,000} \quad \ldots\ldots(2)$$

This shows us that where we base the limit of engine development in the speed of the piston that it is not necessary to know anything about the auto engine save the diameter of the cylinder and the number of cylinders in order to compute the rating of the automobile engines.

Formula for Rating of Autos.

Thus the Association of Licensed Automobile Manufacturers having agreed that 1000 ft. per min. shall be the limit of piston speeds we have for the normal machine in which C = 9786 and n = number of engine cylinders.

$$H.P. = \frac{9786 \times d^2 \times 1000}{24,200,000} n = \frac{n d^2}{2.50} \quad \ldots\ldots(3)$$

Illustration:

A Ford automobile has four cylinders and each cylinder works on the four cycle principle. The cylinder is 3¾ in. bore. What is indicated h.p. rating according to Association of Licensed Automobile Manufacturers?

$$H.P. = \frac{4\ (3.75)^2}{2.5} = 22.5$$

FACTS AND FIGURES OF CURRENT INTEREST

Public spirited civic bodies on both sides of San Francisco Bay are urging the serious consideration of the construction of a mammoth bridge to connect San Francisco and Oakland. It is estimated that the bridge would cost $22,000,000, be five and one-half miles in length, and constitute the greatest undertaking of its kind ever attempted. Estimates of tolls from the bridge traffic, underbidding the present ferry system traffic, show that the bridge would pay for itself within fifteen to twenty years.

* * *

There are about one hundred and ninety-one million domestic animals in the United States, which includes about twenty-one million horses, valued at $2,300,000,000. The mule represents $560,000,000.

* * *

In California, the 190,000 automobiles contribute annually one-half their total fees for highway maintenance which yield anually about one million dollars for that purpose.

* * *

Railroads are the largest users of water in the country. The daily water consumption of the Illinois Central, for instance, is placed at 1,950,000,000 gallons, at a daily expense of $100,000.

* * *

Russia's production in crude petroleum last year was sixty-nine million barrels, a gain of two million barrels in a year.

* * *

Fire losses are on the decrease. The total losses by fire last year in the United States and Canada were $182,836,000, as compared with $235,591.000 the previous year.

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Change of advertising copy should reach this office ten days in advance of date of issue. New advertisements will be accepted up to noon Monday dated Saturday of the same week. Where proof is to be returned for approval, Eastern advertisers should mail copy at least thirty days in advance of date of issue.

CONTENTS

Skin Effect and Its Practical Treatment 77
By Clem Copeland.

Flooding Methods of Irrigation 82
By S. T. Harding.

Letters to the Editor—The Electrical Dealers' Problem 84
By Max Loewenthal.

An Electrically Equipped Home in the San Joaquin Valley ... 86

Prospective Power Market for Irrigation Pumping in Oregon and Washington 87

How to Compute the Horsepower Rating of Your Automobile 89
By Robert Sibley.

Facts and Figures of Current Interest 89

Editorials 90
Skin Effect.
Price Maintenance.
The Rating of Your Automobile.

Personals 92

Meeting Notices 92

Civil Service Examination 92

Findings of the Public Service Commission of Oregon 93

Notes of the California Railroad Commission 93

New Catalogues 93

Book Review 93

News Notes 94

Skin Effect

One effect of the European war has been the substitution of iron for copper as an electrical conductor. Consequently "skin effect," once a subject of purely theoretical interest, has now become a matter of practical concern. The extent to which iron has replaced copper has depended upon the scarcity of the red metal. In Germany, the replacement is reported to have been most marked, as little copper is available for electrical purposes. In America, iron is being used in place of copper only in special instances where the high cost of copper makes its use prohibitive or where high conductivity is not essential.

Skin effect is the crowding of an alternating current to the surface of a wire due to the interior eddy currents resulting from the magnetic flux within the conductor. It causes the effective resistance to be greater for an alternating than for a direct current. With copper or aluminum this effect is negligible except in extremely large cables or at high frequencies. With iron and steel conductors, as well as with bimetallic wire, this factor must be taken into consideration.

Its calculation is extremely difficult, if not impossible, in magnetic conductors. Experiments have been few and far between and erroneous empirical formulas have been carelessly accepted at their face value, thus compounding confusion.

To bring order out of this chaos has been a labor of love to Mr. Clem Copeland, the result of whose extensive researches is initiated in this issue. To many readers the development of the theory of the subject may prove too formidable for intelligent study, but to most of them the practical curves which Mr. Copeland derives should be of inestimable service.

Even the house-wiring contractor will find many copper circuits which are rarely worked at anywhere near the permissible voltage drop, especially where only a few Mazda lamps are supplied with current. There are likewise many lightly-loaded distribution lines where copper can be replaced to economic advantage by iron or steel wire. In long transmission spans, also, it is occasionally advisable to use steel conductors because of the greater strength. Furthermore, high effective resistances are necessary for lightning protective reactances and choke coils to prevent destructive high frequency surges.

In the United States the determination of when and where to use iron and steel conductors is one of dollars and common sense. The temporary saving effected by the cheaper wire should not outweigh the permanent cost of the energy lost by its utilization.

While Mr. Copeland's exhaustive investigations are still incomplete, they form a most valuable contribution to electrical technology. They expose several popular fallacies and point out the incorrectness of commonly-accepted formulas. They indicate one respect in which even the terrible war may eventually benefit humanity by pointing out economies which may be universally practiced in the future. Recently a number of authors have made the error or neglected the proximity effect and have proposed the use of curves which are in no way adapted to the purpose.

Price Maintenance

Price-cutting is the bane of retail selling. Strangely enough the term "retailer" comes from an old French word meaning to cut again. Whereas, originally, it referred to store keepers who bought cloth by the piece and then cut off smaller quantities for sale to customers, it now ironically seems to apply only to the cutting of prices. The small retailer, ordinarily, might not be a price cutter were it not for competition from department stores and from the prevalent belief that price maintenance is illegal.

The department store at first used cut prices as a bait to lure trade in the hope that the profit from other goods would compensate for the loss in handling the standard articles whose prices were cut. As a result, the legitimate dealer cannot afford to sell those articles and the price cutter finally finds that the consumer's confidence in them has been destroyed and so he also ceases to handle them. The market for the manufacturer's product is thus destroyed and the consumer is unable to buy many meritorious articles. Furthermore the consumer does not benefit from this predatory practice as it increases the cost of distributing goods and so adds to the cost of living.

Keensighted business men have good reason to believe that the day of the old-time department store is waning. Once the most highly developed form of retail selling, it is now becoming top-heavy. In large cities the expense of operation is close to thirty per cent. Several large department stores have recently failed, due to high overhead, excessive rents and the discriminating buyer's preference for the specialty shop. It is a universal law of nature that centralization is invariably followed by de-centralization, to be succeeded in turn by a new grouping, and thus the cycle is repeated indefinitely.

This condition has not been overlooked by the department stores themselves, the most modern of which are no longer a series of departments under one management, but rather a store or stores, each department being an independently managed specialty shop. Whether the convenience of several shops under one roof, will appeal to the purchaser more than the isolated shop is problematical.

This subject is one of several symptoms of disease in electrical retail selling which are discussed without gloves elsewhere in these columns by Mr. Max Loewenthal, a man whose wide experience eminently qualifies him to write. He brings up several mooted questions which may invite comment from Journal readers.

The main point to be emphasized, as also brought out by Mr. M. L. Scobey last week, is that aggressive action is essential on the part of the retail electrical dealer.

More fundamental to the success of the business, however, than any economies that may or may not be effected by department store centralization is the principle of one price to all. Price maintenance is a necessity to modern business and as such is not frowned upon by the government. It reduces the waste caused by trade friction, lowers the cost of distributing goods and equalizes competitive conditions. It substitutes confidence in business for the old policy of "let the buyer beware," and the inefficient and time-consuming Chinese method of haggling.

In the course of a recent hearing before the Senate committee on interstate and foreign commerce, Paul H. Nystrom, well known as a former professor of economics and at present a practical retailer, argued that the Supreme Court does not prohibit price maintenance in general, but only that kind which is most economical to the producer, the dealer and the public—the advertising and maintenance of a standard price on trade-marked goods. The chain store is a legal and effective means of accomplishing the same result, but requires large capital and great executive ability.

A remedy for the present undesirable condition was contained in the Stevens bill, which failed to pass the last Congress. The same principles are involved in the Ayres bill now before the House of Representatives, its purpose being "to prevent discrimination in prices and to provide for publicity of prices to dealers and to the public."

Until some such legislation is enacted so as to protect price cutters against themselves reason would at least suggest that the electric retailer take a sensible view of the situation and voluntarily maintain a price which gives him a living profit.

The Rating of Your Automobile

There is nothing more confusing than present methods employed in rating automobiles, and yet every automobile owner should be familiar with a quick and ready rule for arriving at this result.

On another page of this issue will be found a method now universally employed by licensed automobile manufacturers for the rating of their product. Briefly put the rating of any automobile in indicated horsepower developed in the engine cylinders may be ascertained by squaring the cylinder bore in inches and multiplying by the number of cylinders comprising the automobile engine equipment. When this product is divided by two and one-half the rating is at once ascertained. That horsepower is thus independent of the pressure, the length of stroke, and the number of strokes per minute becomes true in the automobile engine due to the fact that the safe limit of piston speed is found to be at one thousand feet per minute. By substituting this limitation in the well known formula for heat engines used in computing indicated horsepower and also by substituting average working pressures prevailing in automobile practice, the formula for rating automobile engines is at once deduced.

It is to be remembered that the result so obtained represents average conditions. Better machines may develop higher output and machines below the average less output. Again when speaking of indicated horsepower developed it must be remembered that this power is that actually prevailing in the engine cylinders and not that delivered at the crank shaft, the transmission gearing or at the rim of the driving wheels. In other words the power actually delivered at the crank shaft is about 80 per cent of the total indicated power, while that finally delivered to the wheel rim is far less.

The formula is, however, extremely useful in computing power rating for state, city or county license fees and is quick and easy of application.

PERSONALS

W. Todd and **W. B. Lewis,** salesmen with Western Electric Company, were at San Francisco this week.

C. R. Hunt, Pacific Coast manager Robbins & Myers Company, has returned to San Francisco from Los Angeles.

Jos. B. Kahn, superintendent of the Alameda municipal lighting plant, has returned from a vacation at Lake Tahoe.

H. Brewster Hall, Pacific Coast manager Pass & Seymour, Inc., is making a six weeks' trip through Southern California.

M. C. Wright, electrical contractor at Eureka, Cal., and **E. H. Kuntz,** electrical contractor at Arcata, Cal., have returned home from a visit to San Francisco.

J. L. White has succeeded **A. Norman** as manager of the Willamette Valley district of the Oregon Power Company at Albany, Wash.

L. A. Somers, manager industrial department Westinghouse Electric & Manufacturing Company at San Francisco, has returned from a two weeks' vacation at Capitola.

W. C. Wurfel, Pacific Coast manager Westinghouse Lamp Company, is spending his vacation with his family in southern California.

C. E. Thompson has joined the San Francisco force of the Westinghouse Electric & Manufacturing Company as treasurer's accounting representative.

W. S. Berry, sales manager Western Electric Company at San Francisco, has returned to his desk from a three weeks' vacation in Sonoma county, Cal.

Mr. George B. Muldaur, formerly connected with the Society for Electrical Development, is now traveling secretary of the National Electric Light Association.

Geo. L. Hedges, engineer Kelman Electric & Manufacturing Company, Los Angeles, Cal., has been transferred to the grade of member of the American Institute of Electrical Engineers.

H. S. Bates of the Westinghouse Lamp Company, Los Angeles, returned from a two weeks' trip through Idaho, where he visited his home in Gooding. He reports business very prosperous in the southern part of the state.

W. C. Johnson, sales engineer with the Westinghouse Electric & Manufacturing Company at San Francisco, acted as captain of Company I of the "rookies" from the business men's Monterey encampment during the preparedness parade at San Francisco.

Geo. D. Longmuir, local manager for the Pacific Power & Light Company, at Pasco, Wash., is expected to return from a six months' trip East about August 10th. **C. R. Young** of the same company's Portland office, is acting as local manager in the interim.

Garnett Young, Pacific Coast manager Telephone Electric Equipment Company, has started on an extended trip to visit the eastern factories he represents. He goes east by way of Los Angeles and expects to attend the Pacific Coast Electrical Supply Jobbers' meeting at Hayden Lake, Idaho, on his way back.

C. P. Gordan, electrician, Port of Seattle, Seattle; **H. S. Haley,** of Leland & Haley, Holbrook Building, San Francisco; **Austin L. Kimball,** Otis Elevator Company, Seattle; **W. J. Mackay,** switchman Pacific Telephone & Telegraph Company, Seattle; **John Spasoff,** substation operator Pacific Gas & Electric Company, San Rafael, Cal.; **L. H. Telfer,** electrical superintendent Great Northern Railway, Wellington, Wash., and **J. H. Wooll,** construction engineer Sierra & San Francisco Power Company, San Francisco, have been elected associate members of the American Institute of Electrical Engineers.

W. A. Brackenridge, vice-president and general manager Southern California Edison Company of Los Angeles, was at San Francisco during the past week.

John A. Britton, chairman of the San Francisco general committee for America's Electrical Week, has appointed the following committee of arrangements to prepare plans for the celebration: **F. H. Leggett,** Western Electric Company; **R. M. Alvord,** General Electric Company; **E. B. Strong,** Journal of Electricity, Power & Gas; **S. V. Walton,** Pacific Gas & Electric Company, and **Paul C. Butte,** Butte Engineering & Electric Company.

B. P. Legare, chief engineer United Railroads of San Francisco, was marshal of the Engineers' Club division in the preparedness parade on July 22d. His aides were: **M. M. O'Shaughnessy, A. A. Hanks, C. W. Merrill, W. A. Cattell** and **Geo. L. Dillman.** The captains were: **H. H. Wadsworth, H. W. Crozier, W. C. Hammatt, E. B. Bumsted, Geo. R. Murphy, R. A. Gould, C. T. Hutchinson, H. L. Hale, A. E. Chandler** and **C. H. Snyder.**

H. V. Carter, having disposed of his holdings in the Pacific States Electric Company, has resigned as president and general manager, after seven years' service, during which period there has been a steady growth in the volume of sales and standing of the company. Because of Colonel Carter's resignation the board of directors has elected **T. E. Bibbins,** president, **W. L. Goodwin,** vice-president in charge of sales, **S. B. Anderson,** treasurer, and **G. I. Kinney,** secretary. Announcement is made that there will be no change made in the general policy of the company.

Thomas E. Collins, of the Pacific Electric Manufacturing Company, was marshal of the Electrical Development and Jovian League division of the preparedness parade at San Francisco, July 22nd, and **E. A. Wilcox,** Great Western Power Company, was assistant marshal; **W. L. McKinley,** Sierra & San Francisco Power Company; **E. M. Cutting,** Edison Storage Battery Company; **W. M. Shepard,** California-Oregon Power Company; **A. Youngholm,** Electric Railway & Manufacturers Company, were aides. **T. E. Bibbins,** of the General Electric Company, was the honorary color-bearer. The captains were **A. H. Halloran,** Journal of Electricity; **Miles F. Steel,** Benjamin Electric Manufacturing Company; **H. E. Sanderson,** Bryant Electric Company; **C. L. Chamblin,** California Electrical Construction Company; **W. D. Tardiff,** Electric Appliance Company; **A. Younghelm,** Electric Railway & Manufacturers Supply Company; **E. D. Shreve** and **F. E. Boyd,** General Electric Company; **M. S. Orrick,** Western Electric Company; **W. R. Dunbar,** Westinghouse Electric & Manufacturing Company; **J. P. Cowperthwaite,** Great Western Power Company, and **F. D. Baker,** Sierra & San Francisco Power Company. The section had nearly 300 men in line.

OBITUARY.

Charles W. H. Kirchhoff of New York, who for twenty years was editor of Iron Age, died at his summer home at Asbury Park, New Jersey, July 23, 1916. He had been a special agent of the United States Geological Survey and president of the American Institute of Mining Engineers. He was born in San Francisco in 1853 and was graduated from the Royal School of Mines at Clausthal, Germany.

MEETING NOTICES.

A joint convention of the Northwest Electric Light & Power Association and the American Institute of Electrical Engineers, is to be held at the New Washington Hotel, Seattle, Wash., September 6, 7, 8 and 9, 1916.

FINDINGS OF THE PUBLIC SERVICE COMMISSION OF OREGON.

The Yamhill Electric Company and Yamhill County Mutual Telephone Company, public utilities within the meaning of Chapter 279 of the General Laws of Oregon for the year 1911, own and operate electric and telephone plants, respectively, in Yamhill county, and insofar as this controversy is concerned, are particularly the owners of certain electric and telephone lines in Dayton, Oregon.

The commission recently issued an order to the Yamhill Electric Company and the Yamhill County Mutual Telephone Company to share equally the expense of removing extremely hazardous conditions existing at First and Ferry streets, and on Third street, Dayton, due to the interlacing of wires. The work must be commenced immediately upon service of a copy of the findings of the commission and completed on or before 20 days thereafter.

NOTES OF THE CALIFORNIA RAILROAD COMMISSION.

The commission has issued an order authorizing the West Riverside Canal Company, of Riverside, to issue seven shares of stock of the par value of $50 per share for the purpose of qualifying directors.

The commission has issued a supplemental order authorizing the Western States Gas & Electric Company to withdraw from the Girard Trust Company of New York $10,506.38 representing 75 per cent cost of additions and betterments in May, 1916.

The commission has authorized the Fresno and Interurban Railway Company to issue $149,700 first mortgage six per cent 25 year bonds, $10,936.27 face value notes and $8100 par value capital stock.

The commission has authorized Pomona Valley Telephone & Telegraph Union to invest as working capital $26,425.88.

The commission has authorized the Midland Counties Public Service Corporation to issue one year promissory notes for $13,957.54 to renew outstanding notes.

The commission has authorized the Southern California Gas Company to issue promissory notes for not more than one year for $49,789.90 to renew outstanding notes.

The East Oakland Water & Electric Company has applied to the commission for authority to borrow $2000 for extensions and improvements to its distributing system.

NEW CATALOGUES.

A two-color, six-page folder describing the new C-H Candle Length Socket has just been issued by The Cutler-Hammer Manufacturing Company of Milwaukee.

A new pamphlet is just out describing the Hubbell Quick Catch wall and ceiling sockets. This socket meets its maximum usefulness for side wall lights designed on the imitation candle style.

Benjamin Electric & Manufacturing Company are distributing a new bulletin on industrial signal systems for factory calls and fire alarms. These employ either motor-driven or vibrating forms, complete wiring diagrams are shown.

Catalogue 11 from The Trumbull Electric Manufacturing Company of Plainville, Conn., comprises an illustrated and descriptive price list of switches, panels, boards, boxes, and other wiring supplies. Its use is greatly facilitated by a convenient center-opening thumb index giving ready access to desired information.

Bulletin number 45603 just issued by the General Electric Company, describes that company's Graded Shunt Resistance Multigraph Lightning Arresters for Alternating Current Constant Potential Circuits. This description is contained in a pamphlet of thirty-two pages, which is illustrated by descriptive diagrams and half-tone illustrations.

The Cutler-Hammer Manufacturing Company of Milwaukee, has just issued an eight-page booklet describing the C-H line of Electrically Heated Candy Manufacturing Appliances. It is claimed that the cleanliness, efficiency and economy of electricity combined with the improved quality and quantity of the product makes electric heat not only desirable but necessary.

The Cutler-Hammer Manufacturing Company of Milwaukee has just issued a small four-page folder describing the new C-H 7700 Line of "Standard" Interchangeable Plugs and Receptacles. The plugs and receptacles described are referred to as "Standard" because they are constructed on "Standard" specifications agreed upon by six large manufacturers of electric wiring specialties.

A large two-color, eight-page folder describing Cutler-Hammer Machine Tool Controllers was distributed to master car builders at their annual June convention at Atlantic City. The new folder is issued by The Cutler-Hammer Manufacturing Company of Milwaukee. The folder describes Machine Tool Controllers in three classes, as Plain Starting, Speed Setting, and Speed Regulating controllers.

The specialties department of the Cutler-Hammer Manufacturing Company of Milwaukee, has just published for distribution a new edition of its Automobile Lighting Switch booklet The new edition states that there are now more than a million C-H switches in use on Packards, Overlands, Studebakers, Buicks, Detroit-Electrics, Haynes, Pullmans, Fords and many other cars equally well known.

Push-Button Press Control is the title of a new four-page newspaper size broadsido just issued by the Printing Equipment Department of the Cutler-Hammer Manufacturing Company of Milwaukee. The new folder describes the Kohler System of Push-Button Press Control which the folder states is now in use in 80 per cent of the printing establishments of this country. The folder is of newspaper size and is built up in columns very similarly to the pewspapers.

BOOK REVIEW.

Principles of Electrical Design, by Alfred Still; 365 pp.; 6x9 in. Published by McGraw-Hill Book Co., New York, and for sale by Technical Book Shop, San Francisco. Price $3.00.

In recent years there have appeared from various publishing houses many books claiming to cover the principles of electrical design. Too often the author has forgotten that he too, was once but a mere inexperienced student without any sense of proportion. As a consequence the student has found in following the text assigned in such instances that frequently bewilderment followed his attempts to carry out in class assignments the ideas the author was trying to convey. Here is a work which, though covering 365 pages of reading matter frankly admits that as a reference book for the designer the text is incomplete. Indeed it is incomplete also as a means of giving the student what he is supposed to get from a course in electrical design, for the simple reason that no art can be mastered by the mere reading of a book. As a reference text, however, for a course of lectures on the subject of electrical design, the book is excellent. The author clinches the proper psychological attitude for the student designer to assume from the start. His introductory chapter is full of wholesome, helpful suggestions as to how the designer should proceed with his work and the mental attitude he should assume to become a successful designer or a successful engineer. Next follow in sequence detailed discussions of theory and problems in design covering electromagnets, continuous current generators and alternating current generators. The painstaking care with which the author has carried out his illustrative problems in design are very helpful. The author is professor of electrical design at Purdue University and an engineer of wide practical experience.

NEWS NOTES

ILLUMINATION.

THE DALLES, ORE.—Mayor Anderson, in his message, urges the advantages of a municipal lighting system.

SAN RAFAEL, CAL.—The board of supervisors will receive sealed bids up to August 8th for installing lights in the Laverne Lighting District.

PARLIER, CAL.—Sealed bids will be received up to August 9th for installing the necessary apparatus for lighting the Del Rey Lighting District.

BOISE, IDAHO.—The Harrison Boulevard Association has adopted a resolution to install 17 250 candlepower lamps in the proposed park on Harrison boulevard.

GOLDFIELD, NEV.—J. B. Fayant has applied to the county commissioners for a gas franchise in this city. The application will be heard on August 9th.

SAN ANSELMO, CAL.—It is expected the town trustees will soon pass a resolution of intention ordering the installation of electroliers along San Anselmo avenue.

WALLA WALLA, WASH.—The county commissioners have awarded the contract for electric fixtures for the court house to the Cascade Electric & Power Company of Seattle at $4000.

BAKER, ORE.—A fund of more than $1000 has been raised towards a system of ornamental street lighting in Baker. The council will next take up the question of which type to select.

SANTA PAULA, CAL.—The committee on street lights has made a report to the chamber of commerce recommending that Marbelite posts, manufactured by the American Cements Products Company be used.

SPOKANE, WASH.—Plans have been adopted for installing, operating and maintaining for a period of ten years, an ornamental street lighting system on Main avenue, from Division to Monroe streets.

LOS ANGELES, CAL.—Ordinances have been adopted by the city council for lighting Wilshire Boulevard between Park View street and Arden boulevard and also for lighting Park View street between Sixth and Seventh streets.

TUCSON, ARIZ.—Installation of ornamental lights on South Stone avenue must be made next year from revenue funds as the bond issue for that purpose is exhausted. It is estimated that $3000 will be necessary to complete the system on the paved streets.

SAN FRANCISCO, CAL.—The Pacific Gas & Electric Company has offered to furnish 110 arc lights of 250 candlepower along the main drive of Golden Gate Park, from Stanyan street to the beach, three miles, at a cost of 13c per lamp per night. The posts are to be ornamental and 12 ft. high.

LOS ANGELES, CAL.—At a meeting of the board of supervisors a contract and bonds for improvement work in the Graham Lighting District were approved and an order was made requesting the chief mechanical engineer to prepare plans and specifications for improvement work in the Bonita Meadows Lighting District.

IRRIGATION.

BAKER, ORE.—Within the next 30 days, Contractor J. A. Hoskins will start work on a $10,000 private irrigation project for the Thomsen Cattle Company of Hereford on upper Burnt River. The company has an excellent reservoir site and will impound the waters of several small streams.

LAGUNA, CAL.—Users of water in the Laguna and Riverdale conservation districts are preparing to take advantage of the proposed building of the Pine Flat storage. Petitions will ask the supervisors to call an election to vote for the establishment of an irrigation district to include these points.

SUISUN, CAL.—A plan for an irrigation district to take water from the San Joaquin River several miles north of Rio Vista and conduct it in a westerly course toward Suisun covering a large area of farm lands is being promoted. A preliminary survey has been made.

KLAMATH FALLS, ORE.—Twenty-nine owners of land in the Wood River Valley, north of Fort Klamath, in the northern part of Klamath county, have been granted clear and undisputed water rights on Anna Creek, according to certificates received from State Engineer Lewis. This controversy has been one of long standing.

CHEHALIS, WASH.—Filing of 18 waterpower rights in the office of the Lewis county auditor here by the Valley Development Company of Portland would indicate that the concern plans at an early date to begin work developing the Packwood holdings which it owns and on which about 11 years ago a large sum of money was spent in engineering.

VISALIA, CAL.—The Kaweah Canal & Irrigation Company, a new organized corporation, intends to store water from Yokohl Creek and the upper Kaweah tributaries with which to irrigate considerable land in Yokohl Valley and west, but properly to do so, according to the engineers, the company must have a certain reservoir situated on the C. H. Lee place in Yokohl Valley. Lee refused to sell the land, 160 acres, and suit has been begun to condemn it for the irrigation reservoir for the canal.

OROVILLE, CAL.—Harry Cauthard, superintendent of the construction work on the Western Canal Company's property, has been in the city for the purpose of conferring with officials of the canal company and the Great Western Power Company relative to the extension of water service to Thermalito. The Western Power Company has a large power plant at Las Plumas and the water that is received there from Lake Almanor could be turned into a ditch and carried over the foothill region to Thermalito.

LINDSAY, CAL.—Bids for the construction of the Lindsay-Strathmore irrigation system have been taken. The work to be done embraces the contruction of 37 wells and well pumping plants, 9 miles of banded wood stave pipe, 3¼ miles 60 in. reinforced concrete pipe or 6½ miles of 48 in. continuous stave redwood pipe, 12 miles of concrete lined ditch, 85 miles riveted steel pressure pipes or reinforced concrete pipe, and two high head pumping plants with an aggregate of 2250 h.p. in motors directly connected to the centrifugal pumps. The maximum time allowed for the completion of the entire work is May 1, 1917.

TRANSMISSION.

BOISE IDAHO.—A petition has been filed with the public utilities commission in the matter of the Southern Idaho Water Power Company to make an extension of its line Rockland.

SAN BERNARDINO, CAL.—The board of supervisors of this county will receive sealed bids up to August 14th for a 50 year franchise over certain public highways as applied for by the Southern Sierra Power Company.

SAN FRANCISCO, CAL.—Bids will be received up to August 9th for machinery to be installed at a temporary power plant on the banks of the Tuolumne River to furnish power for construction work on the Hetch-Hetchy water supply project.

FALL RIVER MILLS, CAL.—The California Power & Manufacturing Company's electric system is in full operation. Electricity is now operating seven pumps and the flour mill.

Journal of Electricity, Power and Gas — Number 4

ELECTRICAL PRICE INDEX

Boxes—Outlet, Galvanized.

Type No.	Cost per 100	List per 100	Sell per 100
8-B. Round outlet and junction box, 4" diam., 1⅝" deep, 4 outlets in sides and 5 in bottom, for ½" or ¾" conduit	.....	25.00	25.00
8-BO. Deep, round outlet and junction box, 4" diam., 1⅝" deep, 4 outlets in sides and 5 in bottom, for ½" or ¾" conduit	.....	25.00	25.00
8-B. Deep, round outlet and junction box, 4" diam., 2¼" deep, 4 outlets in sides and 5 in bottom, for ½", ¾" or 1" conduit, 4 outlets in sides only for 1" conduit	.....	32.00	32.00
600 Round outlet box for combination gas and electric fixtures, 4" diam., 1⅝" deep, 4 outlets in sides and 4 in bottom for ½" conduit. For ¾" conduit, 4 outlets in sides only	.....	45.00	45.00
600-A. Round outlet box for combination gas and electric fixtures, 4" diam., 2¼" deep, 4 outlets in sides and 4 in bottom, for ½" conduit. For ¾" conduit, 4 outlets in sides only	.....	57.00	57.00
8-N. Round receptacle box, 4" diam., 1⅝" deep, 4 outlets in sides only, for ½" or ¾" conduit	.....	25.00	25.00
31 Open cover with ears	.....	14.00	14.00
31 Open canopy cover	.....	14.00	14.00
40 Closed cover	.....	14.00	14.00
62-S Cover flush steel for Federal socket	.....	14.00	14.00
62 Cover flush brass for socket	.....	62.00	62.00
63 Cover lapped brass for socket	.....	65.00	65.00
76 Flat steel cover	.....	12.00	12.00
83 Cover for P. & S. receptacles 61777 and 61977	.....	14.00	14.00
17-A. Round receptacle and outlet box, 3¼" diam., 1⅝" deep, 4 outlets in sides and 1 in bottom, for ½" conduit only	.....	20.00	20.00

The correctness of these suggested selling prices is not guaranteed by the publisher.

PUNCH HERE — PUNCH HERE — Fold Here — PUNCH HERE — PUNCH HERE — PUNCH HERE

Journal of Electricity, Power and Gas — Number 1

ELECTRICAL PRICE INDEX

Attachment Plugs

	Cost	List	Sell
Solid	.....	$ .25	$ .25
Separable	.....	.30	.30
Separable, brass cap	.....	.40	.40
2 Light	.....	1.00	1.00
3 Light	.....	1.50	1.50

Annunciators

Medium Grade House Annunciator

2 number	.....	.....	3.00
4 number	.....	.....	4.00
6 number	.....	.....	5.00
8 number	.....	.....	6.00
10 number	.....	.....	7.00
12 number	.....	.....	8.00
16 number	.....	.....	10.80
20 number	.....	.....	13.60
25 number	.....	.....	17.10

Automatic Set Back

4 number	.....	.....	6.40
6 number	.....	.....	7.90
8 number	.....	.....	9.40
10 number	.....	.....	10.90
12 number	.....	.....	13.15
16 number	.....	.....	16.80
20 number	.....	.....	20.50
24 number	.....	.....	25.00

Elevator Annunciator

4 number, single row	.....	.....	6.75
5 number, single row	.....	.....	7.50
6 number, single row	.....	.....	8.25
7 number, single row	.....	.....	9.00
8 number, single row	.....	.....	9.75
9 number, single row	.....	.....	10.50
10 number, double row	.....	.....	12.00
12 number, double row	.....	.....	13.50
14 number, double row	.....	.....	15.00
16 number, double row	.....	.....	18.00
18 number, double row	.....	.....	20.25
20 number, double row	.....	.....	21.75

The correctness of these suggested selling prices is not guaranteed by the publisher.

Bells and Buzzers

Iron Box

	Cost	List	Sell
2½ in.	.....	.....	.60
3 in.	.....	.....	.60
4 in.	.....	.....	.75
Fancy Gong	.....	.....	1.00
Bell Ringing Transformers, light work.	.....	6.00	5.00
Bell Ringing Transformers, heavy work	.....	13.00	12.00

Lungen Buzzers—Watch Case Buzzers

Lungen Buzzers No. 0	.....	.90	.90
Lungen Buzzers No. 1	.....	.65	.65
Lungen Buzzers No. 2	.....	.80	.80
Lungen Buzzers No. 3	.....	.85	.85
Lungen Buzzers No 4	.....	.90	.90
Brass Box	.....	.60	.60

Single Stroke Bell

Gong	Ohms			
2½	5	.....	3.25	2.65
3	5	.....	3.00	3.00
4	6	.....	3.75	3.50
5	6	.....	5.50	4.60
6	6	.....	6.00	5.00
7	6	.....	7.50	6.75
8	8	.....	10.00	8.50
10	8	.....	11.75	10.00
12	8	.....	14.50	12.00

Skeleton Bells—Class B

2½ in.	.....	.....	2.30
3 in.	.....	.....	2.35
4 in.	.....	.....	2.50
5 in.	.....	.....	4.50
6 in.	.....	.....	4.75
7 in.	.....	.....	7.75
8 in.	.....	.....	8.60

Weatherproof Single Stroke

Gong	Ohms			
2½	5	.....	5.25	4.50
3	5	.....	5.35	4.55
4	6	.....	6.00	5.00
5	6	.....	8.00	6.50
6	6	.....	8.50	7.00
7	6	.....	10.00	8.50
8	8	.....	13.10	11.00
10	8	.....	15.50	12.50
12	8	.....	18.90	15.00

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	Cost	List	Sell
10 in.	.....	.....	14.00
12 in.	.....	.....	15.50
14 in.	.....	.....	40.00
15 in.	.....	.....	52.00

Batteries

Bell Battery	.....	.....	.35
Ignition Battery	.....	.....	.35
Ignition Battery, large size	.....	.....	.85
Samson Battery, complete	.....	.....	2.50
Samson Battery, carbon	.....	.....	1.45
Samson Battery, zincs	.....	.....	.90
Samson Battery, cover	.....	.....	.15
Salammoniac, pkg	.....	.....	.20

Push Buttons

Round Stamped Metal	.....	.....	.25
Elongated Stamped Metal	.....	.....	.50
Cast Bronze, with speaking tube M. P.	.....	.....	1.50
Cast Bronze, elongated, 1 push	.....	.....	1.00
Cast Bronze, elongated, 2 push	.....	.....	1.50
Cast Bronze, with card holder	.....	.....	.85
Cast Bronze, round screw top 2⅜ in.	.....	.....	.70
Cast Bronze, round screw top 1⅝ in.	.....	.....	.60
Cast Bronze, watertight, 2⅝ in.	.....	.....	2.40

Wood

Round, 1½ in. dia.	.....	.....	.15
Round, 1¾ in. dia.	.....	.....	.20

Miscellaneous

Table Clamp	.....	.....	.75
Combination Foot Push	.....	.....	.75
Plain Foot Push	.....	.....	.50
Flat Top Push (table or floor)	.....	.....	1.00
Mite Push	.....	.....	.30
Midget Push, single contact	.....	.....	.35
Midget Push, double contact	.....	.....	.45
Pear Push, wood, plain	.....	.....	.20
Pear Push, wood, fancy	.....	.....	.25
Wood Base Switch, 1 point	.....	.....	.15
Wood Base Switch, 2 point	.....	.....	.20
Dandy Floor Push	.....	.....	1.50
Toggle Bolts	.....	.....	.05

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The company has 14 miles of transmission line and is developing 250 horsepower.

SPOKANE, WASH.—An inland lake six miles long and half a mile wide will be formed near Three Island Park, if plans now being made by the Spokane Valley Power Company are carried out. A franchise for the power company is before the city council.

SALT LAKE CITY, UTAH.—The Utah Power & Light Company has commenced the construction of a new hydroelectric power plant to be located on the Bear River, in Idaho, at Cove, about one and one-half miles below the company's present Grace plant. A force of 350 men are already on the ground and at work on the foundation, flume and dam. This number will be increased, it is said, in the near future to 450, and work on the power house, dam and flume will be pushed vigorously during the summer and fall months, and it is expected the station will be completed in May, 1917. The new plant will be the fourth owned by this company deriving its power from the Bear River. The company's hydroelectric system on this waterway begins at the Bear Lake, which is used as a natural storage reservoir. A canal carries the water of the lake back into the river at those seasons of the year when the water is low. In order to augment the work of the outlet canal, the power company is now constructing an electrically operated pumping station between Mud Lake and Bear Lake. Five electrically driven pumping units having a capacity of 1500 sec. ft. will be installed at this plant, which is known as Lifton. About 200 men are now engaged in making this installation, and the plans call for completion of this work early this fall. It is said that the pumps at Lifton are the largest of their kind ever manufactured.

TRANSPORTATION.

NAMPA, IDAHO.—An ordinance has been passed by the council granting to the Boise Valley Traction Company an Electric Railway franchise on Third and other streets.

NATIONAL CITY, CAL.—Work on the $70,000 extension of the electric railway to Chula Vista by way of Potash and Marmarosa has been resumed by order of the Spreckels companies, following the settlement of the local jitney bus controversy.

POMONA, CAL.—Freight depots will be built soon at Pomona and Claremont by the Pacific Electric Company. It is also announced that the company contemplates building a line from Pomona to the Chino district and a spur line into the foothills near this city.

VISALIA, CAL.—It is generally reported in Visalia that the Southern Pacific Company will electrify its line from Visalia to Porterville in the near future, making a loop for the electric line. The extension will tap some of the most highly developed citrus land of Tulare county.

PHOENIX, ARIZ.—The Carlisle Mining Company will erect an electric generating plant at Duncan or some nearby point on Frisco River. The plant will furnish power for mining operations, and will also probably supply current for an electric road from Duncan to the mine, 13 miles distant.

PASADENA, CAL.—The board of trade here will endeavor to prevent the Pacific Electric Company from putting in the interlocking dispatch system at this time and require it to proceed with plans for the million dollar viaduct eliminating grade crossings. The company already has the plans and figures for this improvement.

FRESNO, CAL.—The Fresno Interurban Railway Company has completed its line as far as the Academy road above Sanger and it is announced that the company has no plans at present for future extensions. The completion of the line to the Academy gives the company 17 miles of tracks in this county.

LINDSAY, CAL.—Actual construction work on the Visalia Electric branch from Exeter to Lindsay, thence to the El Mirador orange district, with its present terminus in the town of Strathmore will commence in about two weeks. The company is now establishing an office on Honolulu street, in this city. The right-of-way has practically all been secured and definitely decided upon, with the exception of the spur into Lindsay.

SAN FRANCISCO, CAL.—The Church street line of the Municipal Railways is complete. The road is ready for operation from Market street along Church street to Twenty-ninth street, but it lacks cars and electric power. Plans were made to connect the road with the municipal line of Van Ness avenue by tracks on Market street, but the city has so far been stopped from constructing the connecting line by injunction proceedings brought by the United Railroads.

TELEPHONE AND TELEGRAPH.

LONG BEACH, CAL.—Announcement has been made that the Pacific Telephone & Telegraph Company will rebuild and extend its lines here at a cost of $23,900.

FILLMORE, CAL.—The Pacific Telephone & Telegraph Company is preparing to install new office equipment here costing $4100, and to make outside improvements to its system costing $1900.

VACAVILLE, CAL.—The St. John's Mine Company of Vallejo has been granted permission to erect a telephone line along the county road from Vallejo Sulphur Springs to the city limits of Vallejo.

GLOBE, ARIZ.—The Mountain States Telephone Compani will start construction immediately on a system here to cost about $50,000. All material and equipment for the work is on the ground.

MT. VERNON, WASH.—Announcement has been made that the Puget Sound Telephone Company will build a two story brick building on the Gates street site to be ready for occupancy by next June.

SANTA FE, N. M.—The Postal Telegraph Company is preparing to rebuild its line from Raton to Albuquerque. Supplies have already been received in Las Vegas.

DOUGLAS, ARIZ.—It has been decided to abandon the present toll line of the Mountain States Telephone & Telegraph Company as soon as a new line can be constructed. Work of surveying for the new line has been started.

DEMING, N. M.—A new toll line is to be constructed by the Mountain States Telephone Company from El Paso to Lordsburg, which will also be extended to Benson, Arizona. The project represents an outlay of $181,000 and is 160 miles in length.

SANTA BARBARA, CAL.—It is considered probable that the merger of the Home and Pacific Telephone Companies here will result in the rebuilding of some of the long distance lines in the county. The merger of the companies is still some months off, however.

CORONADO, CAL.—A new telephone exchange will be built here, the Pacific Telephone Company having signed a lease covering the erection of a concrete building at the corner of Eighth and Orange avenue. The cost of the office equipment is estimated at $25,000.

WINNEMUCCA, NEV.—Hugh L. Thomas, manager of the Utah, Nevada & Idaho Telephone Company, is starting work on the Kennedy extension of the company's line. This line is to be extended from Goldbank's quicksilver mine to the mining camp at the south end of Pleasant Valley.

SAN DIEGO, CAL.—An expenditure of $6000 in the Hillcrest District and in Ocean Beach is being made by the Pacific Telephone Company. In addition to this, $16,000 has been appropriated for additional toll equipment for a composite duplex toll cable from the main office, Los Angeles, to Seventh and Anderson streets, and to Eighth and Central

ALPHABETICAL INDEX TO ADVERTISERS

The letter and number before each name are used in the classified page preceeding

A-1 American Ever-Ready Works of National Carbon Co.. Los Angeles; 755 Folsom St., San Francisco; Seattle.

A-2 Atchison, Topeka & Santa Fe Railway Co..... 673 Market St., San Francisco; 1218 Broadway, Oakland.

B-1 Baker-Joslyn Company..... 5
71 New Montgomery St., San Francisco; 911 Western Ave., Seattle; 353 E. Second St., Los Angeles.

B-2 Benjamin Electric Manufacturing Co..... 590 Howard St., San Francisco.

C-1 Century Electric Co..... 2
906 So. Hope St., Los Angeles; 56 Natoma St., San Francisco; 65 Front St., Portland, Ore.

C-3 Crocker-Wheeler Co..... 87 New Montgomery St., San Francisco; 228 Central Avenue, Los Angeles.

C-4 Cutler-Hammer Manufacturing Co..... 4
579 Howard St., San Francisco; Morgan Bldg., Portland, Ore.; San Fernando Bldg., Los Angeles.

D-4 Davis Slate & Manufacturing Co..... 3
Chicago, Ill.

D-2 Dearborn Drug and Chemical Works..... 11
355 East Second St., Los Angeles; 301 Front St., San Francisco.

E-7 Economy Fuse & Mfg. Co..... Kinzie and Orleans Sts., Chicago.

E-1 Edison Lamp Works of General Electric Co..... Rialto Bldg., San Francisco; 724 So. Spring St., Los Angeles.

E-2 Edison Storage Battery Supply Co..... 11
441 Golden Gate Ave., San Francisco.

E-3 Electric Agencies Co..... 247 Minna Street, San Francisco; Central Building, Los Angeles.

E-6 Electric Novelty Works..... 533 Mission St., San Francisco.

E-4 Electric Storage Battery Co..... 743 Rialto Bldg., San Francisco.

E-5 Electric, Railway & Manufacturing Supply Co..... 11
34 Second St., San Francisco.

F-1 Fairbanks, Morse & Co..... Los Angeles; Portland; 651 Mission St., San Francisco; Seattle; Spokane.

F-3 Federal Sign System (Electric)..... 618 Mission St., San Francisco.

G-1 General Electric Co..... 10
724 So. Spring St., Los Angeles; Worcester Bldg., Portland; Rialto Bldg., San Francisco; Colman Bldg., Seattle; Paulsen Bldg., Spokane.

G-1 General Vehicle Co..... 1117 Van Ness Ave., San Francisco; 331 Wall St., Los Angeles; British Columbia Electric Ry., Ltd., Vancouver, B. C.

H-1 Habirshaw Electric Cable Co., Inc..... (See Western Electric Company.)

H-2 Hemingray Glass Co..... 11
236-240 So. Los Angeles St., Los Angeles; 345 Oak St., Portland; 807 Mission St., San Francisco.

H-3 Haller-Cunningham Electric Co..... 428 Market St., San Francisco.

H-5 Hunt, Mirk & Co..... 141 Second St., San Francisco.

H-7 Hurley Machine Co..... New York and Chicago. (See Pacific States Electric Co.

I-2 Illinois Electric Co..... 261-263 So. Los Angeles St., Los Angeles.

I-3 Interstate Electric Novelty Co..... 111 New Montgomery St., San Francisco.

L-1 Leahy Manufacturing Co..... 3
Eighth and Alameda St., Los Angeles.

L-2 Locke Insulator Manufacturing Co..... 12
(See Pierson, Roeding & Co.)

M-2 McGlauflin Manufacturing Co..... 3
Sunnyvale, Cal.

M-4 Morse Chain Company..... Monadnock Bldg., San Francisco.

M-3 Moore & Co., Charles C..... 3
Van Nuys Bldg., Los Angeles; Spalding Bldg., Portland. Kearns Bldg., Salt Lake City; Sheldon Bldg., San Francisco; Mutual Life Bldg., Seattle; Santa Rita Hotel Bldg., Tucson.

N-1 Nason & Co., R. N..... 151 Potrero Ave., San Francisco.

N-6 National Carbon Company..... 12
Cleveland, Ohio.

N-2 National Conduit & Cable Co., The..... Trust and Savings Bldg., Los Angeles; Rialto Bldg., San Francisco.

N-3 National Lamp Works of G. E. Co..... (All Jobbers.)

N-4 New York Insulated Wire Co..... 629 Howard St., San Francisco.

N-5 Northwestern Pacific Railroad..... 808 Phelan Bldg., San Francisco.

O-1 Okonite Co. (The)..... 12
(All Jobbers.)

P-1 Pacific Electric Manufacturing Co..... 80 Tehama St., San Francisco.

P-2 Pacific States Electric Co..... 2
236-240 So. Los Angeles St., Los Angeles; 61-67 Fifth St. No., Portland; 200-210 Twelfth St., Oakland; 575 Mission St., San Francisco; 307 First Ave. So., Seattle.

P-4 Pelton Water Wheel Co..... 11
2219 Harrison St., San Francisco.

P-5 Pierson, Roeding & Co..... 12
Pacific Electric Bldg., Los Angeles; Rialto Bldg., San Francisco; Colman Bldg., Seattle.

P-6 Pittsburgh Electric Specialties Company..... 202 Aronson Bldg., San Francisco.

P-7 Pittsburgh Piping & Equipment Co..... 12
Monadnock Bldg., San Francisco.

S-1 Schaw-Batcher Company, Pipe Works, The..... 211 J St., Sacramento; 356 Market St., San Francisco.

S-4 Southern Pacific Co..... 2
Flood Bldg., San Francisco.

S-5 Sprague Electric Works..... 3
Rialto Bldg., San Francisco; Colman Bldg., Seattle; Corporation Bldg., Los Angeles; Electric Bldg., Portland; Paulsen Bldg., Spokane.

S-6 Standard Underground Cable Co..... First National Bank Bldg., San Francisco; Hibernian Bldg., Los Angeles; Central Bldg., Seattle, Wash.; 815 Newhouse Bldg., Salt Lake City, Utah.

T-1 Thomas & Co., R..... Pacific States Electric Co. and Western Electric Co., Pacific Coast Representatives.

T-2 Tubular Woven Fabric Company..... 5
Pawtucket, R. I.

U-1 United Sheet Metal Works..... 575 Howard St., San Francisco.

W-1 Wagner Electric Manufacturing Company..... 3
St. Louis, Mo.

W-2 Western Electric Co..... Eighth and Santee Sts., Los Angeles; 1900 Telegraph Ave., Oakland, Cal.; 680 Folsom St., San Francisco; 90 First Ave., Seattle; 45 North Fifth St., Portland, Ore.

W-3 Ward-Leonard Electric Co..... 12
Mt. Vernon, New York.

W-4 Westinghouse Electric and Manufacturing Co..... 6
50-52 East Broadway, Butte; Van Nuys Bldg., Los Angeles; Couch Bldg., Portland; 212 So. W. Temple, Salt Lake City; 165 Second St., San Francisco; Second and Cherry Sts., Seattle; Paulsen Bldg., Spokane.

W-5 Westinghouse Machine Co..... 141 Second St., San Francisco.

W-6 Westinghouse Lamp Co..... (See Westinghouse Electric & Manufacturing Co.)

W-8 Western Pipe & Steel Co..... 444 Market St., San Francisco; 1758 North Broadway, Los Angeles.